1993

Evaluation of Roadside Stabilization and Beautification Plantings in South-Central Utah

United States Department of Agriculture, Forest Service

United States
Department
of Agriculture

Forest Service

**Intermountain
Research Station**

Research Paper
INT-462

March 1993

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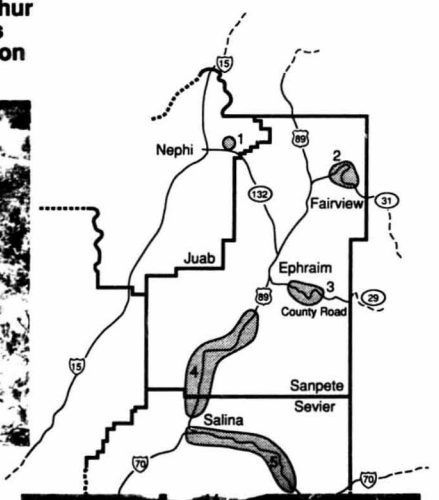

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ACKNOWLEDGMENTS

This work was partially funded by the Federal funds from the Pittman-Robertson W-82-R Project for wildlife habitat restoration (cooperators: Utah Division of Wildlife Resources and Intermountain Research Station) and by Cooperative Agreement No. 22-C-5-INT-004 between the Intermountain Research Station and Snow College. The late A. Perry Plummer of the Intermountain Research Station began this work; we gratefully acknowledge his guidance and stimulation. Gary L. Jorgensen was instrumental in all phases of the work. Robert D. Blauer, Kent R. Jorgensen, Ronald L. Rodriguez, and the Sanpete County Older American Green Thumb crew helped establish or evaluate the plantings. Useful reviews on an earlier version of the manuscript were provided by Cyrus M. McKell, Burns R. Sabey, and Conley Thompson.

RESEARCH SUMMARY

Plantings help stabilize and beautify roadsides. South-central Utah roadsides are particularly challenging to vegetate because of the arid climate, the varied soils and substrata, and the lack of readily available plant materials adapted to the area. Since the 1950's, the Intermountain Research Station of the Forest Service, U.S. Department of Agriculture, has planted hundreds of different types of grasses, forbs, shrubs, and trees along roadsides in Juab, Sanpete, and Sevier Counties. Thirty species planted by direct seeding and 62 species planted by transplanting have established well and are stabilizing soils and beautifying roadsides.

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INTRODUCTION

Numerous roadside plantings have been made in Juab, Sanpete, and Sevier Counties since the mid-1950's under sponsorship of the Intermountain Research Station (Jorgensen and others 1978; Plummer 1970, 1977). The majority of these plantings were established on roadcuts during the 1970's to develop techniques to establish vegetation and to identify plants suitable for stabilizing the site that also harmonize with surrounding vegetation. Roadsides in the Intermountain area are often difficult to revegetate because of the scant precipitation, the varied soils and exposed substrata, and the lack of readily available plant materials adapted to the area (Monsen and Shaw 1983; Plummer 1970; Redente and Hargis 1985; Thames 1977). The sites in Sanpete, Sevier, and Juab Counties are particularly challenging to revegetate because of saline soils and a seasonally dry climate (Price and Evans 1937; Richardson and others 1981; Stevens and others 1983; Swenson and others 1981).

This paper summarizes over 30 years of plant performance. Data were collected in the summers of 1986 and 1987 with three key objectives:

1. To determine the success and adaptability of different plant materials over the wide range of conditions present. Various factors were analyzed, particularly the survival, vigor, and spread of the plants.
2. To assess direct seeding and transplanting to determine which planting technique is most applicable for the various plant species used. The transplants were container stock, including both bareroot wildings dug from native stands and bareroot nursery stock.
3. To characterize, in a general way, the soil and geologic substrate on representative roadside planting sites. The characteristics of these sites were compared with the characteristics of nearby (paired) sites that had not been physically disturbed.

Because of the ecological diversity of these planting sites, the results should have wide application on roadside soils from dry (200 mm or 7.9 inches annual precipitation) to fairly moist (640 mm or 23.6 inches precipitation), from highly alkaline to nearly neutral, from shallow to deep, from low (about 2,585 m or 5,200 ft) to medium elevation (about 2,400 m or 7,870 ft), and on slopes of various aspects.

The plantings were originally for demonstration rather than for detailed experimental tests (Jorgenson and others 1978). This limits the types of tests and analysis that can be conducted; therefore, this presentation is largely a description of the results of different plant materials and their potential. These results should have application at similar sites. To learn more about roadside revegetation in Utah, we recommend Hansen and McKell (1991).

METHODS AND MATERIALS

The plantings (table 1) are located along Highways U.S. 89 in the Sanpete and Sevier Valleys of Sanpete County, Utah 132 in Salt Creek (or Nephi) Canyon, Utah 31 in Fairview Canyon, the Sanpete County Road in Ephraim Canyon, and Interstate 70 in Salina Canyon (fig. 1). The species listed in appendix A include all plants encountered whether planted, adventive, or native. The original planting data and site maps (on file at the Shrub Sciences Laboratory in Provo, UT, and at the Great Basin Experimental Range in Ephraim, UT) were used to locate the 44 sites considered in this report.

Transplants were analyzed for percent survival, average height and crown diameter (centimeters), uniformity, vigor, utilization by animals, percent of ground covered by the canopy, recruitment (reproductive spread vegetatively or by seed) (table 2), and incidental utilization of current growth (generally by small mammals or deer) (appendix B) (Cox 1967). Uniformity, vigor, and utilization were estimated using a zero to nine scale with zero for minimal values (such as death for vigor) and nine for high values. The evaluations were usually done on rows but were sometimes done for individual plants in the case of larger woody plants. Biomass production estimates

Table 1—Evaluation of roadside stabilization and beautification plantings in south-central Utah

Site	Year planted	Location[1]	Size class[2]	Elevation	PPT[3]	Percent slope	Aspect	Type of planting[4]
				Feet	*Inches*			
Ephraim Canyon								
Species sites								
Sainfoin	1979	T17SR3E S10&15	2	5,680-5,760	11	5	240	DS
Forage kochia	1979	T17SR3E S10	2	5,832	12	7	300	DS
Palmer penstemon	1979	T17SR3E S14	2	6,000	13	7	255	DS
Snowberry	1975	T17SR3E S13	1	6,400	14			T
Wormwood	1986 (Spring)	T17SR3E S13	2	6,640	15			T
Grass sites								
Below slide	1968-70	T17SR4E S17&18	1	7,800-7,880	19	70	250	DS
Ponderosa east	1968-70	T17SR4E S18	1	7,600	17	70-84	235	DS
Ponderosa west	1968-70	T17SR4E S18	2	7,400	17	50-80	170	DS
Red cedar turn	1968-70	T17SR4E S18	1	7,240	16	78-91	320	DS
Nephi Canyon	1956-57	T12SR2E S11	3	5,720-5,800	14	15-60	180-220	DS&T
Fairview Canyon								
1. 2 miles from U.S. 89	1976 (March) 1977 (April)	T13SR5E S31	2	6,520	15	62	100	T
2. 2-3 miles from U.S. 89	1976 (March) 1971 (May)	T13SR5E S31	2	6,560	15	62-67	120	T
3. 3 miles from U.S. 89	1976 (March)	T13SR5E S31	1	6,720	16	82	135	T
4. 3.3 miles from U.S. 89	1976	T13SR5E S32	2	6,860	16	72	225	T
5. S bend curve	1962 (May)	T13SR5E S33	2	7,400	17	80	175-235	T
6. Summit	1977 (April)	T13SR5E S24	2	8,760	35			T
South Sanpete/North Sevier								
South Manti	1974	T18SR2E S23	1	5,575	11	W/45 S/52	115 290	T
North Sterling	1974	T18SR2E S27&33	2	5,500	12	51	280	DS
Ninemile	1972-73	T19SR2E S8	2	5,400		64	145	DS
Redmond Jct.	1974	T20SR1E S29	1	5,160	11		165	DS
Redmond Cut	1974	T20SR1E S31	2	5,150	9	31	260	DS
Salina Canyon								
South Salina (ATCA Seeding)	1977 (April)	T21SR1W S36	1	5,200	10	47	25	DS
I-70 on-ramp	1975 (Fall)	T21SR1E S31	2	5,300	11	34	330	DS
Cut 1 (58 + S)[5]	1975 (March) 1974	T22SR1E S3	2	5,690	12	34-45	5-15	T DS(kochia)
2 (72 + S)	1976 (April 1977)	T23SR3E S13	3	7,420	17	47-49	30-255	T
4 (74 + S)	Spring (75,76,77)	T23SR3E S2	2	7,120	14	20-50	175-355	T(iris S of frwy) DS(Rest N of frwy)
5 (77 + S)	1976 (May)	T23SR3E S13	3	7,450	17	45	20	T
6 (77 – N)	1975 (March)	T23SR3E S11	2	7,320	15	35	230	T
7 (76 – N)	1974	T23SR3E S11	2	7,320	15	42	255	DS
8 (77 – N)	1975 (May)	T23SR3E S2	2	7,220	14	21	250	T
9 (74 + N)	1975 (April)	T23SR3E S2	1	7,220	14	28	190	T
10 (74 – N)	1975 1975 (May)	T23SR3E S2	3	7,220	14	21-35	210-240	DS(kochia) T
11 (74 – N)	1976	T23SR3E S11	2	7,320	15	45	215	T

(con.)

Table 1 (Con.)

Site	Year planted	Location[1]	Size class[2]	Elevation	PPT[3]	Percent slope	Aspect	Type of planting[4]
				Feet	*Inches*			
13 (73 – N)	1975 (May)	T23SR3E S3&11	3	7,280	15	18-25	230-250	T
14 (71 – N)	1971	T23SR4E S19	2	7,420	17	46	155	T,DS
15 (68 – N)	1976 (March & April)	T22SR2E S14	2	6,240	13	90	75	T
16 (61 – N)	1975	T22SR2E S7	2	5,800	12	31	160	DS
17 (60 – N)	1975 (February)	T22SR1E S1	3	5,740	13	54	160-165	DS(forage kochia)
	1975 (March)					26-50	160	T
18 (59 – N)	1976	T22SR1E S2	2	5,700	12	52	160	DS
19 (58 – N)	1975 (March)	T22SR1E S3	2	5,670	12	18	240	DS
20 (58 – N)	1975 (February)	T22S1RE S3	2	5,660	12	55	165	DS
Mouth of canyon	1976	T21SR1E S31	1	5,300	10	21	55	DS
I-70 off-ramp	1975	T21SR1E S31		5,300	11	26	175	DS

[1]Township, range, and section.
[2]Size classes: 1 = <0.1 ha (¼ acre); 2 = 0.1-1.0 ha (¼-2½ acres); 3 = >1.0 ha (>2½ acres).
[3]Approximate precipitation (PPT) values extrapolated from Price and Evans 1937; Stevens and others 1983; Richardson and others 1981.
[4]T = Transplants; DS = Direct seedings, including screenings.
[5]The code after the cut refers to mile markers and side of highway: the number is the mile marker, – means before and + means after the mile marker; N means north and S means south side of the road. For example, 58 + S means beyond milepost 58, south side of road.

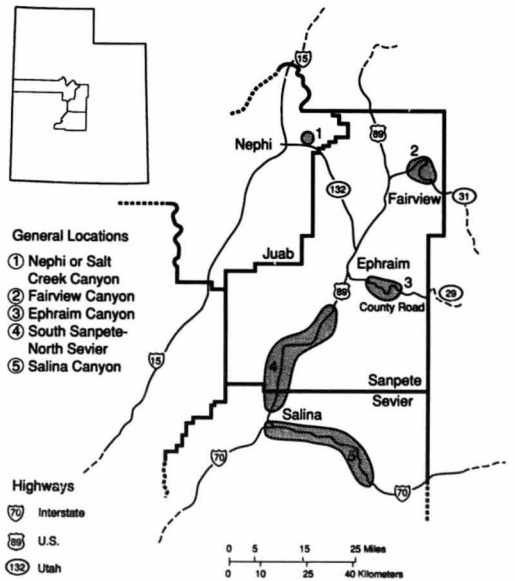


Figure 1—Location of roadside planting study sites in south-central Utah.

Table 2—Roadcut species spreading vegetatively or by seed (recruitment)

Species[1]	Nephi	Fairview	Lower Sanpete Valley	Salina Canyon
Grasses				
Agropyron intermedium				At cut 10, formed patch 9 m across
A. repens				At cut 10, five plots grew together to form uniform patch 4.5 by 12.5 m; at cuts 13 and 17, spread out 1.5-2.0 m beyond plot
Calamagrostis epigeios				At cut 14, spread 1 m wide
Elymus salinus				At cut 17, spread 1 m wide
Forbs				
Artemisia ludoviciana	Some spread			Good spread at some sites; at cut 10 formed one patch 1.8 m by 9 m and one patch 2 m by 2 m; spread up into *Agropyron repens*
Aster chilensis var. *adscendens*		Some spread by rhizomes		
Iris germanica			Considerable spread from original plots	Excellent spread on ramp cut
Salvia sclarea	Excellent spread by seed			
Sphaerophysa salsola				Increased from 12 originally planted to 87 total plants in patch 16 by 6 m.
Shrubs and trees				
Acer negundo		Formed thicket with *Salix purpurea* after erosion covered bases of plants		
Artemisia abrotanum		Erosion and sloughing covered bases of plants; layering and root sprouting		Some spread by seed and layering (cut 11)
A. cana ssp. *cana*				Excellent: two to three times more new plants than originally planted at cut 2
A. nova	Spread by seed		Slight, two young plants	
Caragana arborescens		24 seedlings within 1.5 m of plot		
Colutea arborescens	Considerable spread	Six seedlings		Spread out 1.5 m, some seedlings at cut 2
Cotoneaster acutifolia		Bases covered; formed thicket		
Elaeagnus commutata				Spread out 2 m uphill and downhill from plot 2; 270 new plants along row at cut 2
Fraxinus pennsylvanica		Large rock slid down covering part of plot; sprouts coming out from under rock		
Kochia prostrata			Extensive spread	Extensive spread at cut 5, one row of transplants spread out to 1.3 m and is solid except for one space; (con.)

Table 2 (Con.)

Species[1]	Nephi	Fairview	Lower Sanpete Valley	Salina Canyon
Kochia prostrata (Con.)				at cut 17 spread out 1 m with 22 new plants; at cut 19, five accessions of *Kochia prostrata* spread over area covering 16 rows
Lonicera tatarica	Some layering			
Lycium barbarum		Some vegetative spread—eight small plants around one large plant		Some layering at cut 2; some by seed at cut 5, with 23 young plants uphill from row within 1.5 m; at cut 8 spread 1.5 m—very vigorous for site; at cut 10 spread 3 m downhill; at cut 17 spread 1 m uphill and 1 m downhill from row, 44 young plants
Prunus americana		Considerable spread over 8-m area at site 5; at site 6 showed 355 percent increase		
P. andersonii				Some layering at cut 10
P. besseyi		Plot grew into thicket; bases buried by erosion		
P. spinosa		Bases buried by erosion—much sprouting; two young plants 1 m east of plot		
Purshia tridentata	Some layering			
Rhus glabra	Some root (rhizome) sprouting			
R. aromatica var. *trilobata*	Excellent spread—formed large thicket			
Robinia pseudoacia		One seedling		
Rosa hansenii		Some spread		
Rosa species		Excellent spread		Some spread up to 1.5 m at cut 2
R. woodsii	Considerable root (rhizome) sprouting			Excellent spread by layering—52 new plants spread 2 m downhill at cut 13; some layering at cut 17
Salix purpurea		Considerable spread—formed thicket with *Acer negundo*		
Shepherdia argentea				Good spread 1.5-2 m; one plot increased from 11 original plants to 46 new plants at cut 2
Symphoricarpos oreophilus	Considerable layering	Some layering (a patch developed at site 4, apparently from natural vegetation)		
Syringa vulgaris	Some root (rhizome) sprouting	Erosion covered bases; vegetative spread up to 2m		

[1]For common names see appendix A.

for some species used the method of Pechanec and Pickford (1937).

Direct seeding plots were analyzed similar to the transplant plots, except that the number of plants present per plot was determined instead of percent survival (appendix C) (Cox 1967).

Taxonomic nomenclature generally follows Welsh and others (1987). However, names for grasses follow Hitchcock (Hitchcock and Chase 1971; Plummer and others 1977). Big sagebrush (*Artemisia tridentata*) and rabbitbrush (*Chrysothamnus*) subspecific taxa are treated as subspecies, not varieties (McArthur 1983; McArthur and Meyer 1987; McArthur and others 1979). We recognize cliffrose (*Cowania*) as a distinct genus (McArthur and others 1983). Origin of plant species (native or introduced) was taken from Welsh and others (1987) or Albee and others (1988), unless otherwise noted. The most successful species are described briefly. The ecological measures of cover class and density (Cox 1967; Daubenmire 1959) were used to measure plant performance. Both measures were determined by using 1-m-square (10.8-ft-square) quadrats placed along transects through the various study sites. Our density values are given as the average number of each species of plant per quadrat. Our cover class values were modified slightly from those suggested by Daubenmire to cover classes 1, <1 percent; 2, 1-5 percent; 3, >5-25 percent; 4, >25-50 percent; 5, >50-75 percent; 6, >75-95 percent; 7, >95-100 percent. For computing mean values of percent cover, the midrange value for each cover class was used: 0.5, 3.0, 15.0, 37.5, 62.5, 85.0, and 97.5. The standard errors from the mean values are also provided.

Unless noted otherwise, the quadrats were placed on alternate sides of a 25-m tape starting at zero. The interval between quadrats ranged from 3 m (9.8 ft) on the narrow sites to 10 m (32.8 ft) on the broader sites. Within each site the quadrats were equally spaced. At least five quadrats were sampled from each transect. The transects were located by laying the tape across the site and extending it in the direction of the most extensive spread. On the more variable sites, one or more transects were laid on grade across the site and one laid perpendicular, more or less parallel to the slope (aspect). More detail for individual sites is given in the Results and Discussion section.

The number of individuals of each species within a quadrat was recorded. For rhizomatous species each vertical stem was counted or visually estimated, unless otherwise noted. A visual estimate was made of the percentage of quadrat covered by the canopy of each species (Daubenmire 1959). The cover classes of litter, rock, bare ground, and cryptogams were recorded, along with the aspect, and slope of each transect.

Soils were analyzed at six sites, two along U.S. 89 in the southern part of Sanpete County and four along Interstate 70 in Salina Canyon, Sevier County. At each site, soils were sampled along the roadcuts and at a nearby (paired) site that was not physically disturbed. Although both cut and fill sites were planted, only soils from the cut sites were sampled. The following characteristics were evaluated: soil texture (percent clay, percent sand, and percent silt), pH (acidity), CEC (cation exchange capacity), SAR (sodium adsorption ratio), EC (electrical conductivity in mmhos), percent organic matter, AWHC (average water-holding capacity), water-holding capacity at –0.3 bar (standard field capacity) and at –15 bar (standard permanent wilting point), NO_3 (nitrate nitrogen), K (potassium), P (phosphorus), Fe (iron), Zn (zinc), Cu (copper), and Mn (manganese) (Klute 1986; Page 1982; Richards 1954).

A mixture of grasses and sweetclover (*Melilotus officinalis*) was planted by the Utah State Department of Transportation on the exposed roadcuts in Salina Canyon as portions of Interstate 70 were completed. The grass mixture included fairway crested wheatgrass (*Agropyron cristatum*), desert crested wheatgrass (*A. desertorum*), intermediate wheatgrass (*A. intermedium*), and, on more favorable sites, smooth brome (*Bromus inermis*). On the more severe sites with shallow, alkaline soils, little or no grass became established, although good stands developed on more favorable sites (Jorgensen and others 1978).

Site characteristics (soil types and average precipitation) were taken from Greer and others 1981; Johnson 1989; Swenson and others 1981; Trickler and Hall 1984. Even though soil taxonomic units and, in some cases, soil series are cited, the revegetation plots were located on drastically disturbed slopes which exposed the soils' highly variable, stratified geologic parent materials. True soil horizons rarely existed at these sites. Consequently, soil type had little relationship with the substrate where the plantings took place.

RESULTS AND DISCUSSION

The results and discussion are organized by site, emphasizing successful species. Our discussion begins with the northernmost sites and progresses with those to the south.

Nephi Canyon

The planting site analyzed in Nephi Canyon was not on a roadcut, but rather on a west-facing hillside (aspect ranging from 180 to 220 degrees) 44 m (144 ft) off the north side of Utah Highway 132 near milepost 36 (fig. 2). It is on Xeric Torriothents-Rock outcrop soil complex (Trickler and Hall 1984). The shallow soils are composed of shaly or clay loams with limited permeability. They are highly susceptible to water erosion. The area's fragility is exacerbated by its historic use as a sheep driveway, with attendant overgrazing and erosion problems. Past land use and soil conditions present challenges to plant establishment and growth. Precipitation here averages 340 mm (13.5 inches) per year. This approximately 1-ha (2.4-acre) site was principally planted in 1956 and 1957, with bareroot transplants and some direct seeding. The planting extended from the base up the slope, which ranged from 15 to 60 percent. Later transplants were made in 1961, 1969, and 1970. In 1971 a direct seeding plot was added (table 1).

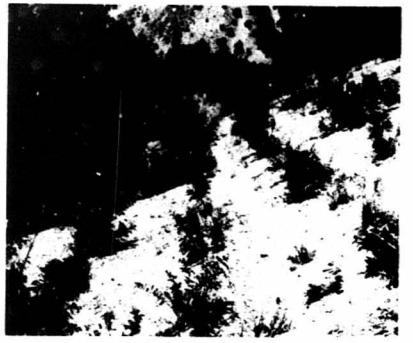


Figure 2—Plantings on west-facing slope, Nephi Canyon, Juab County, UT.

Data from this area were difficult to analyze. Most of the original transplants never established, or succumbed early. Some survivors have spread vegetatively or by seed, forming stands of mixed species in some cases. Some plots where plants did not survive were replanted in subsequent years. It was virtually impossible to locate many of the original plots.

Data were gathered at this site by two rather arbitrary methods. A preliminary survey was made of the entire site listing all surviving planted species, their relative numbers and survival, and any natural spread. From this survey, nine of the best performing species (eight shrubs and one forb) were selected for further analysis of height, crown, vigor, and utilization (table 3 and appendix A). Thirty established, healthy plants of each of these species

Table 3—Performance of nine of the best performing species at Nephi Canyon site after 30 years including mean ($\bar{x}$) values and standard error (se)

Species[1]	Height ($\bar{x}$ ± se)	Crown ($\bar{x}$ ± se)	Vigor ($\bar{x}$ ± se)	Current utilization ($\bar{x}$ ± se)	Average total utilization (determined visually)[2]
Artemisia nova[3]	32.76 ± 2.77	65.06 ± 6.41	6.90 ± 0.28	0.03 ± 0.03	2
Artemisia tridentata ssp. *tridentata*	74.50 ± 6.37	96.00 ± 7.14	6.10 ± 0.34	0.13 ± 0.06	6 (5.9 ± 0.5)[4]
Colutea arborescens	182.56 ± 6.28	203.36 ±10.30	8.26 ± 0.17	1.00 ± 0.00	2
Lonicera tatarica	59.26 ± 6.46	80.26 ± 8.08	6.60 ± 0.30	0.33 ± 0.08	3
Purshia tridentata[5]	74.40 ± 6.86	120.73 ± 6.04	7.53 ± 0.27	0.60 ± 0.10	4 (4.5 ± 0.1)
Rhus aromatica var. *trilobata*[6]	214.00 ± 5.79	324.96 ±14.62	8.13 ± 0.22	0.76 ± 0.07	2
Rosa woodsii[7]	14.92 ± 1.88	20.20 ± 2.71	5.68 ± 0.33	0.08 ± 0.05	T
Salvia sclarea[8]	17.70 ± 2.98	32.10 ± 2.33	7.13 ± 0.24	0.93 ± 0.10	T (insect only)
Symphoricarpos oreophilus	40.36 ± 2.82	110.40 ± 6.99	7.96 ± 0.18	0.33 ± 0.08	3

[1]For common names see appendix A.
[2]Utilization was on a scale of 0 = no use, 5 = moderate use, 9 = heavy use, T = trace use.
[3]There were two main plantings of black sagebrush. They were on opposite sides of the hillside planting. About half of the plants had new seed stalks, so they were much taller than those without.
[4]The basin big sagebrush was heavily hedged, although current use was light.
[5]Three of the antelope bitterbrush bushes had layered.
[6]Ten of the 30 skunkbush sumac plants measured were planted as transplants in two rows of five. These rows ran parallel from south to north. All 10 transplants appear to have survived and have grown into a thicket that has enlarged by layering. The thicket is now 14 m long, 5.5 m wide on the south end, and 4.5 m wide on the north end (fig. 4). The measurements given the 10 plants were extrapolated.
[7]The roses were small and scattered over the area where they were originally planted. No rows were obvious, so we evaluated whatever was alive. Eleven of the 25 plants evaluated were reproducing vegetatively by root sprouting.
[8]The Clary sage had spread by seed to form numerous young plants. Only established plants, more than a year old, were evaluated.

were selected and evaluated. Only 25 Woods rose (*Rosa woodsii*) plants were available for rating. Next, 20 quadrats were placed near, usually on the lower side, of established plants that included the planted species. Studying these quadrats helped determine how well the planted species were competing with other vegetation and gave an indication of their spread (table 4 and appendix A).

Two of the most vigorous, well-established species at this site were common bladdersenna (*Colutea arborescens*) (fig. 3) and skunkbush sumac (*Rhus aromatica* var. *trilobata*) (fig. 4 and table 3). Of the shrubs listed in table 4, common bladdersenna had the highest density of young plants ($\bar{x}$ = 4.6 ± 1.98/m²) (fig. 5). Common bladdersenna is a leguminous shrub native to southern Europe and northern Africa that grows up to 3.5 m (11.5 ft) tall. Skunkbush sumac is a native shrub indigenous in the area of the study site that often forms thickets in riparian communities. It may reach 2.5 m (8.2 ft) in height. Other shrubs that had a mean ($\bar{x}$) density of greater than one per square meter were common lilac (*Syringa vulgaris*) ($\bar{x}$ = 3.55 ± 2.63), Woods rose ($\bar{x}$ = 1.40 ± 1.08) (fig. 6), black sagebrush (*Artemisia nova*)

Table 4—Nephi Canyon quadrat study, 1987. Twenty quadrats 1 meter square across the slope face adjacent to (usually below) established plants.[1] Species with mean ($\bar{x}$) cover class more than 0.25 are listed with their standard error (se)[2]

Species[3]	Cover class $\bar{x}$ ± se	Density $\bar{x}$ ± se
Grasses		
Bromus japonicus	8.90 ± 2.62	42.90 ±10.55
B. tectorum	2.20 ± 1.86	8.40 ± 6.50
Oryzopsis hymenoides	2.02 ± 1.02	0.70 ± 0.27
Sitanion hystrix	1.65 ± 1.03	0.45 ± 0.27
Forbs		
Alyssum alyssoides	3.47 ± 1.34	26.65 ± 9.68
Arenaria fendleri	0.75 ± 0.74	2.05 ± 2.04
Aster chilensis var. *adscendens*	0.35 ± 0.20	0.85 ± 0.46
Convolvulus arvensis	0.77 ± 0.74	2.15 ± 2.04
Cynoglossum officinale	2.05 ± 1.01	2.75 ± 1.24
Iva axillaris	3.92 ± 1.47	6.05 ± 2.14
Melilotus alba	0.92 ± 0.75	0.35 ± 0.25
Rubia tinctoria	0.75 ± 0.74	0.50 ± 0.49
Salvia sclarea	2.62 ± 1.98	1.65 ± 1.13
Sphaeralcea coccinea	0.90 ± 0.75	0.50 ± 0.37
Shrubs		
Artemisia nova	1.50 ± 1.03	1.30 ± 0.96
Cercocarpus montanus	3.37 ± 2.07	0.40 ± 0.28
Colutea arborescens	9.87 ± 3.86	4.60 ± 1.98
C. arborescens (canopy)	11.12 ± 5.49	—
Elaeagnus angustifolia (canopy)	3.12 ± 3.12	—
Lonicera tatarica	1.87 ± 1.87	0.55 ± 0.54
Quercus gambelii (canopy)	4.25 ± 4.24	—
Rhus glabra	0.75 ± 0.74	0.10 ± 0.10
R. aromatica var. *trilobata*	4.65 ± 2.62	0.55 ± 0.30
R. aromatica var. *trilobata* (canopy)	3.75 ± 2.58	—
Rosa woodsii	0.90 ± 0.75	1.40 ± 1.08
Symphoricarpos oreophilus	5.62 ± 3.07	1.05 ± 0.59
Syringa vulgaris	3.75 ± 2.58	3.55 ± 2.63
S. vulgaris (canopy)	0.75 ± 0.74	—
Litter	21.65 ± 4.70	
Bare ground	26.50 ± 3.59	
Rock	50.87 ± 5.77	

[1]Mature plants established by transplanting or direct seeding, 1956 and 1957.

[2]The following species had $\bar{x}$ < 0.25 cover class: Grass—*Agropyron cristatum, A. spicatum,* and *A. trichophorum;* Forbs—*Chaenactis douglasii, Cirsium calcareum, Lactuca serriola, Malcolmia africana, Melilotus officinalis, Physaria chambersii,* and *Tragopogon dubius;* Shrubs—*Artemisia tridentata* ssp. *tridentata, Chrysothamnus nauseosus* ssp. *hololeucus, Cowania stansburiana,* and *Juniperus osteosperma.*

[3]For common names see appendix A.

Figure 3—Common bladdersenna, Nephi Canyon, Juab County, UT.

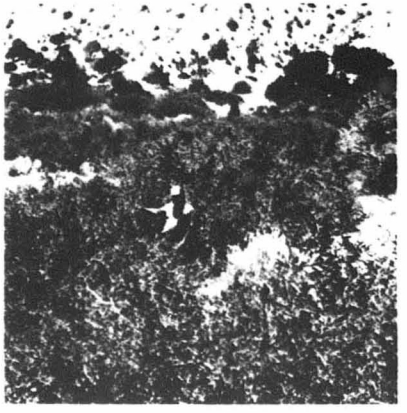


Figure 4—Skunkbush sumac thicket, Nephi Canyon, Juab County, UT. (This thicket was originally two separate rows of transplanted plants).

Figure 5—Common bladdersenna showing recruitment, Nephi Canyon, Juab County, UT.

Figure 6—Woods rose recruitment, Nephi Canyon, Juab County, UT.

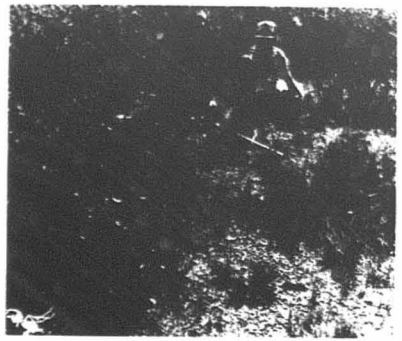


Figure 7—Black sagebrush mature plants (lower left corner) and young seedlings (see arrows) to the right and within the quadrat, Nephi Canyon, Juab County, UT.

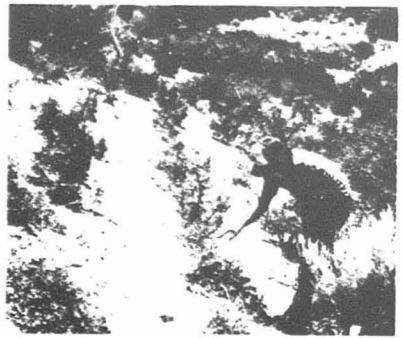


Figure 9—Tatarian honeysuckle in the row just above the researcher, Nephi Canyon, Juab County, UT (note mountain snowberry above the honeysuckle).

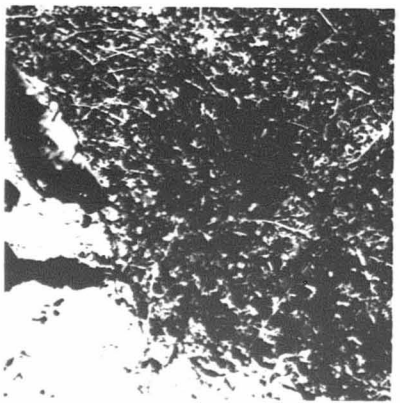


Figure 8—Mountain snowberry showing recruitment by layering, Nephi Canyon, Juab County, UT.

($\bar{x}$ = 1.30 ± 0.96) (fig. 7), and mountain snowberry (*Symphoricarpos oreophilus*) ($\bar{x}$ = 1.05 ± 0.59) (fig. 8 and table 4). All of these shrubs, along with tatarian honeysuckle (*Lonicera tatarica*) (fig. 9), showed recruitment at this site.

Four weedy species had a mean density greater than five. Two of these, Japanese chess (*Bromus japonicus*) ($\bar{x}$ = 42.90 ± 10.55) and cheatgrass (*Bromus tectorum*) ($\bar{x}$ = 8.40 ± 6.50), were grasses; two, pale alyssum (*Alyssum alyssioides*) ($\bar{x}$ = 26.65 ± 9.68) and poverty sumpweed (*Iva axillaris*) ($\bar{x}$ = 6.05 ± 2.14), were forbs (table 4). Only poverty sumpweed is native.

Two common, native shrubs planted on the site, basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) and antelope bitterbrush (*Purshia tridentata*), showed the greatest utilization (table 3). Each was heavily hedged (fig. 10).

Clary sage (*Salvia sclarea*), the only forb among the nine best performing species, showed excellent recruitment by seed (fig. 11). A biennial, clary sage is native to the northern and eastern portions of the Mediterranean Basin. It has been widely planted as an ornamental or medicinal plant, and for use as a clearing or flavoring agent for alcoholic beverages (Grieve 1931). At our study site it has spread up to 20 m (68 ft) from the original planting.

Fairview Canyon

Plantings on six roadcuts were analyzed in Fairview Canyon. The sites ranged in elevation from 1,988 m (6,520 ft) at the mouth of the canyon, to 2,671 m (8,760 ft) near the summit of Utah Highway 31. The slope of these roadcuts ranged from 62 to 82 percent; the aspects ranged from 100 to 235 degrees. Annual precipitation ranges from 400 to 900 mm (15.8 to 35.4 in) depending on elevation,

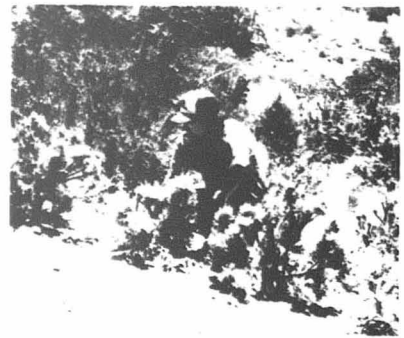


Figure 10—Heavily hedged basin big sagebrush and antelope bitterbrush, Nephi Canyon, Juab County, UT. The bitterbrush is behind and to the left of the sagebrush.

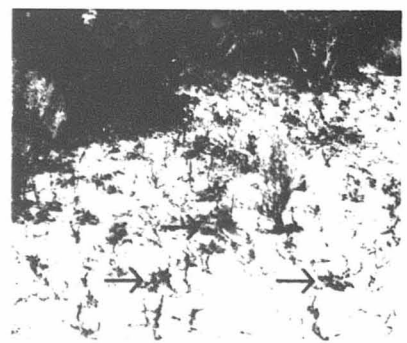


Figure 11—Clary sage showing recruitment (arrows) from seed, Nephi Canyon, Juab County, UT.

mostly during October to May (Richardson and others 1981) (table 1). Soils are generally mollisols, commonly of the Lizzant, Mower, Lundy, and Kitchell series. All plantings were on very steep slopes in soils formed in alluvium derived from limestone, sandstone, and shale (Hutchings and Murphy 1981; Swenson and others 1981). Most of these sites were planted in 1976 and 1977. Site 5 was planted in 1962. Part of site 2 was planted in 1971. Only transplants were used (table 1). Over half of the species were exotics obtained from Plumfield Nursery in Nebraska. The rest were container stock grown locally, or wildings or cuttings of oldman wormwood (*Artemisia abrotanum*).

It is unfortunate this study was not undertaken a few years earlier. The heavy snowfall and spring storms during 1983 and 1984 saturated the soils, causing severe mudslides, sloughing, and erosion on some of the roadcuts. Many well-established plants and entire plots were destroyed. Others were disrupted and rearranged, making it difficult or impossible to find them. Nevertheless, some useful data were obtained from these sites.

Twenty-eight of the 38 surviving species in Fairview Canyon had a vigor rating of 8 or 9 (table 5). Twenty-two species had a combined survival rate of 10 percent or better (table 6).

Table 7 shows the performance rating of 21 species. The remaining 17 species were not listed because the percent survival could not be determined or only one plant survived. Thus, no uniformity rating could be given. The performance ratings presented in table 7 are based on survival, uniformity, and vigor.

Oldman wormwood was the only species found at all six sites (fig. 12). Its performance rating was intermediate compared to the other species. Unlike most of them, however, oldman wormwood reproduces vegetatively, especially when its base is buried by sloughing and erosion (fig. 13). At five sites, the number planted originally was not recorded (table 5). In all likelihood, they were planted over a number of years as cuttings and space became available. If this information had been available, a more accurate percent survival could have been determined. The performance rating of oldman wormwood would undoubtedly have been higher. Plummer (1974) details transplanting and rooting techniques for this lacy-leafed, aromatic shrub native to the Mediterranean (Hall and Clements 1923). Its deep, extensive root system makes the plant very useful for subsurface stabilization and surface erosion control. In our study area, as throughout the Intermountain area, oldman wormwood does not produce seed. It remains in the areas where it has been established (Plummer 1977).

Four *Prunus* species did well. Their performance ratings (maximum possible value = 27) are as follows: blackthorn (*P. spinosa*) (21), American plum (*P. americana*) (18), Bessey cherry (*P. besseyi*) (18), and sloe cherry (*P. siberica*) (17) (table 7). These four *Prunus* species, none of which are indigenous, performed better in Fairview Canyon than transplants of native chokecherry (*Prunus virginiana* var. *melanocarpa*). Twelve native chokecherry were planted at site 1, but only one survived; thus,

Table 5—Performance of species transplanted on roadcuts in Fairview Canyon[1]

Species[2]	Number planted						Number survived						Percent survival					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Acer ginnala	—	—	—	—	20	—	—	—	—	—	2	—	—	—	—	—	10	—
A. negundo	—	15	—	—	20	—	—	2	—	—	13	—	—	13.3	—	—	[3]65	—
Amelanchier alnifolia	—	—	—	—	20	—	—	—	—	—	6	—	—	—	—	—	30	—
Artemisia abrotanum	?	?	46	?	?	7	2	75	3	[4]83	25	49	—	—	6.5	—	—	??
A. ludoviciana	—	—	—	—	?	—	—	—	—	—	1	—	—	—	—	—	—	—
A. tridentata	?	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Aster chilensis	—	—	—	—	?	—	—	—	—	—	2	—	—	—	—	—	—	—
Caragana arborescens	12	—	—	—	19	—	1	—	—	—	5	—	8.3	—	—	—	26	—
Celtis occidentalis	—	—	—	—	20	—	—	—	—	—	4	—	—	—	—	—	20	—
Chrysothamnus nauseosus ssp. *hololeucus*	?	—	—	—	?	—	[5]3	—	—	—	4	—	—	—	—	—	—	—
Colutea arborescens	?	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—
Cornus sericea	—	—	—	—	20	—	—	—	—	—	2	—	—	—	—	—	10	—
Cotoneaster acutifolia	—	15	—	—	20	—	—	1	—	—	20	—	—	6.7	—	—	100	—
Cowania stansburiana	?	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Cupressus arizonica	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	12.5	—	—
Forestiera neomexicana	—	—	—	20	—	—	—	—	—	1	—	—	—	—	—	5	—	—
Fraxinus pennsylvanica	—	—	—	—	10	—	—	—	—	—	4	—	—	—	—	—	40	—
Iris germanica	?	?	108	—	?	—	1	4	16	—	3	—	—	—	14.8	—	—	—
Lonicera tatarica	—	19	—	—	—	—	—	4	—	—	—	—	—	26.7	—	—	—	—
Lycium barbarum	—	—	—	—	?	—	—	—	—	—	[6]9	—	—	—	—	—	—	—
Morus alba var. *tatarica*	—	—	—	—	10	—	—	—	—	—	4	—	—	—	—	—	40	—
Pinus edulis	—	22	—	—	—	—	—	1	—	—	—	—	—	4.6	—	—	—	—
Populus fremontii	—	—	—	—	?	—	—	—	—	—	[7]	—	—	—	—	—	—	—
Prunus americana	—	19	—	—	17	11	—	1	—	—	4	39	—	6.7	—	—	24	355
P. besseyi	—	50	—	—	20	—	—	10	—	—	5	—	—	20.0	—	—	25	—
P. siberica	—	—	—	—	20	—	—	—	—	—	7	—	—	—	—	—	35	—
P. spinosa	—	—	—	—	20	—	—	—	—	—	12	—	—	—	—	—	60	—
Prunus virginiana var. *melanocarpa*	12	—	—	—	—	—	1	—	—	—	—	—	8.3	—	—	—	—	—
Quercus gambelii	?	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Ribes aureum	?	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Robinia pseudoacacia	—	23	—	—	—	—	—	1	—	—	—	—	—	4.4	—	—	—	—
Rosa hansenii	—	15	—	—	20	—	—	3	—	—	6	—	—	20.0	—	—	30	—
Rosa species	—	—	—	—	?	—	—	—	—	—	[7]	—	—	—	—	—	—	—
Sambucus cerulea	—	—	—	16	—	—	—	—	—	1	—	—	—	—	—	6.3	—	—
Salix purpurea	—	—	—	—	20	—	—	—	—	—	8	—	—	—	—	—	40	—
Symphoricarpos oreophilus	?	—	—	—	9	—	15	—	—	—	[7]	—	—	—	—	—	22	—
Syringa villosa	—	—	—	—	20	—	—	—	—	—	3	—	—	—	—	—	15	—
S. vulgaris	?	15	—	—	20	—	1	4	—	—	7	—	—	26.7	—	—	35	—

Species[2]	Average height						Average crown						Uniformity					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Acer ginnala	—	—	—	—	49	—	—	—	—	—	94	—	—	—	—	—	9	—
A. negundo	—	234	—	—	186	—	—	234	—	—	122	—	—	7	—	—	8	—
Amelanchier alnifolia	—	—	—	—	119	—	—	—	—	—	134	—	—	—	—	—	7	—
Artemisia abrotanum	98	92	87	124	98	56	78	74	43	86	110	45	9	5	7	7	6	5
A. ludoviciana	—	—	—	—	77	—	—	—	—	—	230	—	—	—	—	—	—	—
A. tridentata	19	—	—	—	—	—	16	—	—	—	—	—	—	—	—	—	—	—
Aster chilensis	—	—	—	—	53	—	—	—	—	—	140	—	—	—	—	—	8	—
Caragana arborescens	212	—	—	—	252	—	293	—	—	—	259	—	—	—	—	—	7	—
Celtis occidentalis	—	—	—	—	163	—	—	—	—	—	63	—	—	—	—	—	3	—
Chrysothamnus nauseosus	84	—	—	—	42	—	146	—	—	—	52	—	8	—	—	—	7	—
Cotoneaster acutifolia	—	29	—	—	108	—	—	64	—	—	111	—	—	—	—	—	8	—
Colutea arborescens	57	—	—	—	—	—	66	—	—	—	—	—	4	—	—	—	—	—
Cornus sericea	—	—	—	—	62	—	—	—	—	—	82	—	—	—	—	—	8	—
Cowania stansburiana	39	—	—	—	—	—	72	—	—	—	—	—	—	—	—	—	—	—
Cupressus arizonica	—	—	—	64	—	—	—	—	—	97	—	—	—	—	—	—	—	—
Forestiera neomexicana	—	—	—	132	—	—	—	—	—	205	—	—	—	—	—	—	—	—
Fraxinus pennsylvanica	—	—	—	—	250	—	—	—	—	—	124	—	—	—	—	—	3	—

(con.)

Table 5 (Con.)

Species[2]	Average height						Average crown						Uniformity					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Iris germanica	20	23	21	—	26	—	18	20	23	—	33	—	—	7	5	—	4	—
Lonicera tatarica	—	34	—	—	—	—	—	69	—	—	—	—	—	4	—	—	—	—
Lycium barbarum	—	—	—	—	46	—	—	—	—	—	52	—	—	—	—	—	6	—
Morus alba var. *tatarica*	—	—	—	—	50	—	—	—	—	—	54	—	—	—	—	—	6	—
Pinus edulis	—	63	—	—	—	—	—	79	—	—	—	—	—	—	—	—	—	—
Populus fremontii	—	—	—	—	45	—	—	—	—	—	164	—	—	—	—	—	8	—
Prunus americana	—	232	—	—	147	67	—	173	—	—	99	46	—	—	—	—	6	6
P. besseyi	—	19	—	—	41	—	—	42	—	—	96	—	—	6	—	—	9	—
P. siberica	—	—	—	—	229	—	—	—	—	—	153	—	—	—	—	—	5	—
P. spinosa	—	—	—	—	290	—	—	—	—	—	114	—	—	—	—	—	7	—
Prunus virginiana var. *melanocarpa*	21	—	—	—	—	—	32	—	—	—	—	—	—	—	—	—	—	—
Quercus gambelii	180	—	—	—	—	—	352	—	—	—	—	—	—	—	—	—	—	—
Ribes aureum	59	—	—	—	—	—	120	—	—	—	—	—	—	—	—	—	—	—
Robinia pseudoacacia	—	373	—	—	—	—	—	347	—	—	—	—	—	—	—	—	—	—
Rosa hansenii	—	17	—	—	53	—	—	27	—	—	43	—	—	8	—	—	6	—
Rosa species	—	—	—	—	24	—	—	—	—	—	31	—	—	—	—	—	8	—
Sambucus cerulea	—	—	—	273	—	—	—	—	—	422	—	—	—	—	—	—	—	—
Salix purpurea	—	—	—	—	206	—	—	—	—	—	90	—	—	—	—	—	7	—
Symphoricarpos oreophilus	24	—	—	—	64	—	38	—	—	—	199	—	4	—	—	—	7	—
Syringa villosa	—	—	—	—	70	—	—	—	—	—	56	—	—	—	—	—	8	—
S. vulgaris	66	42	—	—	95	—	69	65	—	—	107	—	—	6	—	—	8	—

Species[2]	Vigor						Utilization						Spread					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Acer ginnala	—	—	—	—	7	—	—	—	—	—	1	—	—	—	—	—	—	—
A. negundo	—	9	—	—	8	—	—	—	—	—	1	—	—	—	—	—	[8]	—
Amelanchier alnifolia	—	—	—	—	6	—	—	—	—	—	1	—	—	—	—	—	—	—
Artemisia abrotanum	9	8	8	9	8	8	—	—	—	—	1	—	—	—	—	[8]	—	—
A. ludoviciana	—	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	—	—
A. tridentata	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aster chilensis	—	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	[8]	—
Caragana arborescens	9	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	[8]	—
Celtis occidentalis	—	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	—	—
Chrysothamnus nauseosus ssp. *hololeucus*	9	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	—	—
Colutea arborescens	8	—	—	—	—	—	—	—	—	—	—	—	[10]	—	—	—	—	—
Cornus sericea	—	—	—	—	7	—	—	—	—	—	1	—	—	—	—	—	—	—
Cotoneaster acutifolia	—	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	—	—
Cowania stansburiana	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cupressus arizonica	—	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Forestiera neomexicana	—	—	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fraxinus pennsylvanica	—	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	[10]	—
Iris germanica	7	8	7	—	7	—	1	1	1	—	1	—	—	—	—	—	—	—
Lonicera tatarica	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lycium barbarum	—	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	—	—
Morus alba var. *tatarica*	—	—	—	—	6	—	—	—	—	—	1	—	—	—	—	—	—	—
Pinus edulis	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Populus fremontii	—	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	—	—
Prunus americana	—	9	—	—	9	8	—	—	—	—	1	—	—	—	—	—	[11]	[12]
P. besseyi	—	8	—	—	9	—	—	—	—	—	1	—	—	—	—	—	[13]	—
P. siberica	—	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	—	—
P. spinosa	—	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	[14]	—
Prunus virginiana var. *melanocarpa*	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Quercus gambelii	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ribes aureum	8	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
Robinia pseudoacacia	—	9	—	—	—	—	—	—	—	—	—	—	[10]	—	—	—	—	—
Rosa hansenii	—	8	—	—	8	—	—	—	—	—	1	—	—	—	—	—	[15]	—

(con.)

Table 5 (Con.)

Species[2]	Vigor						Utilization						Spread					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Rosa species	—	—	—	—	7	—	—	—	—	—	1	—	—	—	—	—	([16])	—
Sambucus cerulea	—	—	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Salix purpurea	—	—	—	—	9	—	—	—	—	—	1	—	—	—	—	—	([3])	—
Symphoricarpos oreophilus	7	—	—	—	8	—	—	—	—	—	1	—	—	—	—	—	([17])	—
Syringa villosa	—	—	—	—	6	—	—	—	—	—	1	—	—	—	—	—	—	—
S. vulgaris	7	8	—	—	9	—	—	—	—	—	1	—	—	—	—	—	([18])	—

[1]Sites and extent of sloughing: site 3, some sloughing, in one part; site 4, all of this cut has slipped, causing loss of most of the transplants; site 5, heavy erosion and sloughing occurred at this site, burying the bases of most of the transplants and making it difficult to determine the number of plants present.
[2]For common names see appendix A.
[3]The *Acer negundo* has formed a thicket with the *Salix purpurea*. The bases of many *Artemisia abrotanum* plants were buried by sloughing, and are showing some layering and root spreading. A *Symphoricarpos oreophilus* patch formed below the *A. abrotanum* plants and is spreading vegetatively like the *A. abrotanum*. There is no record of it being planted here, so it may be a natural population that established.
[4]This is an approximate number, because of vegetative reproduction.
[5]These *Chrysothamnus nauseosus* ssp. *hololeucus* plants may be from natural revegetation.
[6]There is one large plant. The eight smaller ones around it may have been produced vegetatively.
[7]The transplant has spread so much vegetatively that it is impossible to determine the number of plants present.
[8]Some vegetative spread.
[9]*Caragana arborescens*—about 24 seedlings within 1.5 m of plot.
[10]One well-developed tree. A large rock slid down on the upper part of the plot. The ash tree is sprouting out from under the part covered by the rock.
[11]Considerable spread over an 8-m-square area.
[12]*Prunus americana* had a 355 percent increase at this site.
[13]Bases buried so the plants appear to be a thicket.
[14]Erosion has covered bases of the plants, and considerable sprouting has occurred. The number of original plants still alive was estimated. There were two young plants 1 m east of the plots.
[15]Some vegetative spread.
[16]Excellent vegetative spread.
[17]Bases of the plants covered by erosion. A patch 1.5-2 m square has formed.
[18]Considerable vegetative spread growing out 2 m from the plot.
[19]Seedlings, six for *Colutea arborescens* and one for *Robinia pseudoacacia*.

Table 6—Species with a combined survival rate of 10 percent or better at the six Fairview Canyon study sites

Species[1]	Percent survival
Cotoneaster acutifolia	60.0
Prunus spinosa	60.0
Acer negundo	42.9
Fraxinus pennsylvanica	40.0
Morus alba var. *tatarica*	40.0
Salix purpurea var. *lambertiana*	40.0
Prunus americana	37.2(?)[2]
Prunus siberica	35.0(?)[3]
Syringa vulgaris	31.4
Amelanchier alnifolia	30.0
Lonicera tatarica	26.7
Rosa hansenii	25.7
Symphoricarpos oreophilus	22.0
Prunus besseyi	21.4(?)[3]
Celtis occidentalis	20.0
Caragana arborescens	19.4
Syringa villosa	15.0
Iris germanica	14.8
Cupressus arizonica	12.5
Acer ginnala	10.0
Cornus sericea	10.0
Artemisia abrotanum	10.0[4]

[1]For common names see appendix A.
[2]This species showed considerable increase, particularly at site 6. Eleven plants were originally planted, but because of reproduction, 39 are now present in the row. The exact number of surviving original plants could not be counted at sites 5 and 6.
[3]Best estimate, see table 5.
[4]From field observations, this species is believed to have a survival rate greater than 10 percent, but because so few plants were planted originally, in some cases, and because of vegetative reproduction, an exact percentage cannot be given.

Table 7—Performance rating of transplants on Fairview Canyon roadcuts[1]

Species[2]	Performance rating
Cotoneaster acutifolia	22
Prunus spinosa	21
Acer negundo	20
Salix purpurea var. *lambertiana*	19
Prunus americana	18
Prunus besseyi	18
Syringa vulgaris	18
Caragana arborescens	17
Prunus siberica	17
Rosa hansenii	17
Acer ginnala	16
Artemisia arbortanum	16
Cornus sericea	15
Lonicera tatarica	15
Morus alba var. *tatarica*	15
Symphoricarpos oreophilus	15
Syringa villosa	15
Fraxinus pennsylvanica	14
Artemisia ludoviciana	13
Amelanchier alnifolia	12
Celtis occidentalis	12

[1]Performance rating was determined by combining the average percent survival, uniformity, and vigor rating. The rating for percent survival was determined on the following basis: 1-10% = 0, 11-20% = 1, 21-30% = 2, 31-40% = 3, 41-50% = 4, 51-60% = 5, 61-70% = 6, 71-80% = 7, 81-90% = 8, 91-100% = 9. The ratings for uniformity and vigor, which are also given on a 1 to 9 basis, were averaged for each trait and added to the survival rating. Thus, the higher the performance rating number, the better the species did. The maximum value would be 9 + 9 + 9 = 27.
[2]For common names see appendix A.

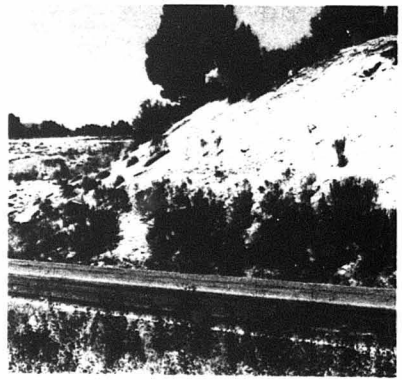


Figure 12—Oldman wormwood established from transplants or cuttings on Fairview Canyon roadcut, Sanpete County, UT.

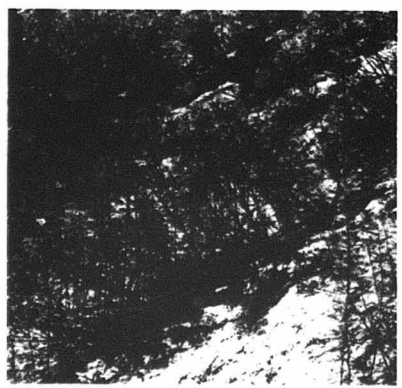


Figure 13—Oldman wormwood showing vegetative recruitment, Sanpete County, UT.

a performance rating was not determined for it. Chokecherry was also planted at sites 3, 4, and 6, but only survived at site 1. At sites 3 and 5 slippage took out any surviving chokecherry. Otherwise, chokecherry performance might have been more nearly on par with the species that were not indigenous.

Peking cotoneaster (*Cotoneaster acutifolia*) and blackthorn had the highest performance rating in Fairview Canyon (table 7). Both showed high vigor, rated 9. Cotoneaster survivors were slightly more uniform, rated 8, than blackthorn, rated 7. Both showed good vegetative reproduction, sprouting from bases buried by sloughing and erosion. Because of the thickets that were formed, the number of survivors of both species could only be estimated (table 5). Peking cotoneaster and blackthorn are both deciduous, rosaceous shrubs that grow to heights of 1 to 3.5 m (3.3 to 11.5 ft). Peking cotoneaster is native to northern China, blackthorn to Europe and western Asia (Bailey Hortorium Staff 1976).

Boxelder (*Acer negundo*), a native, and purpleosier willow (*Salix purpurea* var. *lambertiana*), a European introduction, rated next to Peking cotoneaster and blackthorn in their performance (table 7). At site 5 their bases were covered by sediment, and they both sprouted vegetatively to form an intermixed thicket. They were originally planted in adjacent plots.

Ephraim Canyon

Six different plantings were analyzed on roadcuts in Ephraim Canyon along the county road (formerly Utah Highway 29, now connecting with Utah Highway 29 in Emery County). At the oldman wormwood and mountain snowberry sites, height and crown of individual plants were measured and surviving plants were counted. At the other four sites (sainfoin, penstemon, forage kochia, and grass), quadrats were read to determine cover class and density for the species growing there (table 8 and appendix A).

Sainfoin Site—This site is along the Ephraim Canyon Road about 1.6 km (1 mi) below the mouth of the canyon. It was seeded in a hydromulch slurry of fertilizer, seed, and mulch along the borrow pits (fig. 14) on both sides of the road. Elevation ranges from 1,732 to 1,756 m (5,686 to 5,760 ft). Precipitation averages from 270 to 330 mm (11 to 13 in). Surface runoff from the paved road increases the amount of moisture available. The soil type is Sigurd gravelly loam. The slope is 5 percent, with an aspect of 240 degrees (table 1).

Common sainfoin (*Onobrychis viciifolia*) was planted in 1979 on a roadfill following highway construction. Sainfoin blooms in the spring, adding beauty and color to the roadside. It remains green throughout the summer, and basal leaves stay green all winter. Besides adding color to the area, it helps to stabilize the borrow pits and roadcuts in this relatively dry area. Deer seek out sainfoin throughout the year. This leguminous, perennial forb is a Eurasian introduction that has proved useful in

Figure 14—Sainfoin seeded alongside Ephraim Canyon Road, Sanpete County, UT.

revegetating disturbed lands in the American West (Wasser 1982).

To sample this planting, we laid a 100-m transect line through the middle of the strip starting on the upper end of the south roadbank. The planting extends along the road for about 1.8 km (1.1 mi). Ten quadrats were spaced 10 m apart along the transect. The percent cover and density of the species found in the quadrats are listed in table 8.

Sainfoin is well established here. It had a mean percent cover of 36.75 ± 6.90 (cover class 4), almost three times greater than cheatgrass. Cheatgrass, an annual weed, had the next highest cover (13.40 ± 3.29, cover class 3). Sainfoin had a mean density of 13.40 ± 2.36. Only two other species, both annual, introduced grasses, had a higher density. Cheatgrass had a density of 66.50 ± 10.35, followed by jointed goatgrass (*Aegilops cylindrica*), which had a density of 14.40 ± 2.37. Three other species had cover classes greater than 2: fairway crested wheatgrass (6.30 ± 2.38), field bindweed (*Convolvulus arvensis*) (4.10 ± 3.72), and yellow salsify (*Tragopogon dubius*) (2.40 ± 1.44) (table 8). Of all the species growing at this site, only sainfoin and crested wheatgrass were planted here. 'Sodar' streambank wheatgrass (*Agropyron riparium*), also planted here in 1979, was not observed in or out of the quadrats.

Penstemon Site—Palmer penstemon (*Penstemon palmeri*) was planted by direct seeding in 1979 along an Ephraim Canyon roadfill at an elevation of about 1,829 m (6,000 ft). The site was about 0.7 km (0.4 mi) east of the sainfoin site in a very stony loam soil of the Donnardo soil series. Palmer penstemon is an evergreen, native perennial with a thick, fibrous taproot and tall flowering stalks (up to 1.2 m or 4 ft) (Welsh and others 1987). 'Cedar' Palmer penstemon is a released cultivar (Stevens and Monsen 1988). The collection that became 'Cedar' was planted at the study site, although it had not been released at the time of seeding. Precipitation is 300 to 360 mm (12 to 14 in). This fill slope area gains some supplemental water from runoff from the paved surface. The area has a slope of 7 percent with an aspect of 255 degrees (a west-southwest exposure) (table 1). Penstemon was located principally in a strip 190 m (623 ft) long and 7 m (23 ft) wide along the north side of the road (fig. 15). The upper edge of the strip started 2 to 3 m (6.6 to 9.8 ft) from the edge of the asphalt and sloped down, away from the road about 7 m (23 ft). Plants were scattered in the upper 50 m (164 ft) and lower 100 m (328 ft). They were most abundant in an area 40 m (131 ft) long between the two scattered areas. As at the sainfoin site, a 100-m transect line was laid through the middle of the strip starting on the upper end. Ten quadrats were read. They were centered on the transect tape 10 m (3.28 ft) apart.

Penstemon was less dominant at this site than sainfoin was at the sainfoin site. The penstemon site had a greater mix of species (fig. 16). Five species had a higher percent cover than penstemon:

- white rubber rabbitbrush (*Chrysothamnus nauseosus* ssp. *hololeucus*) (9.80 ± 3.86 percent cover, cover class 3)
- field bindweed (9.00 ± 2.44, cover class 3)
- Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) (7.75 ± 6.26, cover class 3)
- jointed goatgrass (6.95 ± 2.22, cover class 3)
- curlycup gumweed (*Grindelia squarrosa*) (6.65 ± 2.29, cover class 3)

The percent cover for Palmer penstemon was 5.10 ± 2.19 (cover class 3). Nine other species rated lower (table 8 and appendix A).

Penstemon had a mean density of 1.30 ± 0.49 per quadrat. It was in each of the five upper quadrats. Although it was not found in the lower five quadrats, it was scattered nearby. The most numerous species, based on density, were two annual,

Table 8—Results of quadrat studies on seeded roadsides in Ephraim Canyon[1] including mean ($\bar{x}$) values and standard error (se)

Species[2]	Percent cover ($\bar{x}$ ± se)	Density ($\bar{x}$ ± se)
Sainfoin site[3]		
Major seeded species		
Onobrychis viciifolia	36.75 ± 6.90	13.40 ± 2.36
Grasses		
Aegilops cylindrica	7.30 ± 2.11	14.40 ± 2.37
Agropyron cristatum	6.30 ± 2.38	2.50 ± 1.01
Bromus tectorum	13.40 ± 3.29	66.50 ± 10.35
Forbs		
Aster chilensis var. *adscendens*	0.35 ± 0.29	0.40 ± 0.30
Convolvulus arvensis	4.10 ± 3.72	2.70 ± 2.11
Erodium cicutarium	0.30 ± 0.29	0.10 ± 0.10
Tragopogon dubius	2.40 ± 1.44	2.00 ± 0.61
Litter	50.00 ± 6.41	
Bare ground	3.35 ± 1.96	
Rock	18.70 ± 5.37	
Palmer penstemon site[4]		
Major seeded species		
Penstemon palmeri	5.10 ± 2.19	1.30 ± 0.49
Grasses		
Aegilops cylindrica	6.95 ± 2.22	22.80 ± 7.90
Agropyron cristatum	1.95 ± 1.47	0.70 ± 0.33
Bromus japonicus	2.30 ± 1.45	13.10 ± 5.07
Bromus tectorum	0.30 ± 0.08	4.20 ± 1.71
Dactylis glomerata	0.30 ± 0.29	0.10 ± 0.10
Oryzopsis hymenoides	1.55 ± 1.49	0.20 ± 0.19
Poa bulbosa	2.80 ± 1.42	5.90 ± 2.46
Sitanion hystrix	5.00 ± 2.19	1.70 ± 0.55
Forbs		
Convolvulus arvensis	9.00 ± 2.44	9.60 ± 3.07
Grindelia squarrosa	6.65 ± 2.29	3.40 ± 1.05
Shrubs		
Artemisia tridentata ssp. *wyomingensis*	7.75 ± 6.26	0.20 ± 0.13
Chrysothamnus nauseosus ssp. *hololeucus*	9.80 ± 3.86	0.40 ± 0.16
Litter	12.35 ± 1.77	
Bare ground	12.15 ± 3.46	
Rock	65.50 ± 6.14	
Forage kochia site[5]		
Major seeded species		
Kochia prostrata[6]	19.20 ± 11.23	12.80 ± 5.23
K. prostrata[7]	4.20 ± 2.78	3.40 ± 1.72
K. prostrata seedlings[6]	0.40 ± 0.10	2.80 ± 1.39
K. prostrata seedlings[7]	0.20 ± 0.12	4.60 ± 4.11
Grasses		
Aegilops cylindrica[6]	6.60 ± 3.47	61.40 ± 30.28
A. cylindrica[7]	6.70 ± 0.58	10.60 ± 6.72
Agropyron cristatum[6]	11.70 ± 6.94	8.20 ± 3.97
A. cristatum[7]	9.60 ± 3.34	6.80 ± 2.22
Bromus tectorum[6]	0.10 ± 0.10	2.40 ± 2.40
B. tectorum[7]	0.60 ± 0.60	11.00 ± 11.00
Festuca ovina var. *duriuscula*[6]	0.10 ± 0.10	1.00 ± 1.00
F. ovina var. *duriuscula*[7]	0	0
Oryzopsis hymenoides[6]	0.10 ± 0.10	0
O. hymenoides[7]	0	0
Poa bulbosa[6]	4.90 ± 2.57	15.20 ± 5.06
P. bulbosa[7]	4.40 ± 2.70	8.60 ± 4.53
Sitanion hystrix[6]	0	0
S. hystrix[7]	0.70 ± 0.58	0.60 ± 0.40

(con.)

Table 8 (Con.)

Species[2]	Percent cover ($\bar{x}$ ± se)	Density ($\bar{x}$ ± se)
Forbs		
Convolvulus arvensis[6]	0	0
C. arvensis[7]	4.20 ± 2.78	11.60 ± 8.02
Erodium cicutarium[6]	0	0
E. cicutarium[7]	0.60 ± 0.60	5.00 ± 5.00
Grindelia squarrosa[6]	0	0
G. squarrosa[7]	0.10 ± 0.10	0.20 ± 0.20
Onobrychis viciifolia[6]	0.60 ± 0.60	0.20 ± 0.20
O. viciifolia[7]	6.60 ± 3.47	2.40 ± 1.12
Ranunculus testiculatus[6]	0.30 ± 0.12	1.20 ± 0.73
R. testiculatus[7]	0.40 ± 0.10	5.80 ± 2.17
Sphaeralcia coccinea[6]	0	0
S. coccinea[7]	0.70 ± 0.58	2.00 ± 1.54
Shrubs		
Chrysothamnus viscidiflorus puberulus[6]	0.70 ± 0.58	0.40 ± 0.24
C. viscidiflorus puberulus[7]	0	0
Gutierrezia sarothrae[6]	0	0
G. sarothrae[7]	0.10 ± 0.10	0.60 ± 0.60
Tetradymia canescens[6]	0.10 ± 0.10	0.20 ± 0.20
T. canescens[7]	0	0
Cryptogams[6]	5.40 ± 2.40	
Cryptogams[7]	1.90 ± 0.67	
Litter[6]	33.50 ± 8.82	
Litter[7]	24.00 ± 5.51	
Bare ground[6]	19.70 ±11.03	
Bare ground[7]	33.00 ± 4.50	
Rock[6]	6.80 ± 3.37	
Rock[7]	7.80 ± 2.93	
Below slide		
Grasses		
Agropyron spicatum var. *inerme*	3.07 ± 2.05	10.42 ± 5.79
A. trachycaulum	25.71 ± 5.86	45.14 ±10.47
Bromus inermis	13.64 ± 8.53	46.71 ±36.67
Dactylis glomerata	0.42 ± 0.42	0.14 ± 0.14
Poa pratensis	4.28 ± 2.76	10.00 ± 6.48
Forbs		
Astragalus cicer	0.42 ± 0.42	
A. convallarius	2.14 ± 2.14	0.42 ± 0.42
Balsamorhiza sagittata	2.14 ± 2.14	0.14 ± 0.14
Convolvulus arvensis	0.07 ± 0.07	0
Erigeron species	0.42 ± 0.42	0.14 ± 0.14
Lathyrus lanszwertii	2.14 ± 2.14	1.28 ± 1.28
Stellaria jamesiana	0.07 ± 0.07	0.86 ± 0.86
Shrubs		
Artemisia abrotanum	0.07 ± 0.07	0.85 ± 0.85
Litter	48.21 ±11.28	
Bare ground	16.28 ± 5.84	
Rock	8.85 ± 5.13	
Ponderosa east		
Grasses		
Agropyron spicatum var. *inerme*	11.25 ± 3.75	23.25 ± 9.91
A. trachycaulum	16.87 ± 7.73	32.00 ±13.83
Bromus inermis	3.75 ± 3.75	15.50 ±15.50
Phleum pratense	0.12 ± 0.12	0.25 ± 0.25
Forbs		
Astragalus convallarius	0.75 ± 0.75	1.25 ± 1.25
Erigeron species	0.12 ± 0.12	0.25 ± 0.25

(con.)

Table 8 (Con.)

Species[2]	Percent cover ($\bar{x}$ ± se)	Density ($\bar{x}$ ± se)
Shrubs		
Rosa woodsii	3.75 ± 3.75	1.00 ± 1.00
Litter	26.25 ± 6.49	
Bare ground	56.25 ± 6.25	
Rock	15.00 ± 0	
Ponderosa west		
Grasses		
Agropyron spicatum var. *inerme*	1.55 ± 1.49	2.30 ± 1.89
A. trachycaulum	26.25 ± 3.74	65.80 ± 6.95
Bromus inermis	6.35 ± 2.37	13.00 ± 5.63
Poa pratensis	0.30 ± 0.29	0.90 ± 0.89
Forbs		
Astragalus convallarius	0.30 ± 0.29	0.10 ± 0.10
Convolvulus arvensis	1.55 ± 1.49	1.50 ± 1.29
Cynoglossum officinale	1.50 ± 1.50	0.70 ± 0.69
Iris germanica	1.50 ± 1.50	0.20 ± 0.19
Medicago sativa	1.50 ± 1.50	0.30 ± 0.29
Shrubs		
Quercus gambelii	3.75 ± 3.74	0
Rosa woodsii	1.50 ± 1.50	0.30 ± 0.29
Litter	39.55 ± 7.19	
Bare ground	38.25 ± 7.83	
Rock	12.60 ± 1.60	
Red cedar		
Grasses		
Agropyron intermedium	2.50 ± 2.50	2.00 ± 2.00
A. repens	2.50 ± 2.50	16.00 ±16.00
A. trichophorum	16.25 ± 4.90	108.16 ±38.96
Bromus inermis	13.00 ± 2.00	46.33 ±18.59
Forbs		
Astragalus species	0.08 ± 0.08	0.16 ± 0.16
Astragalus convallarius	0.58 ± 0.49	0.66 ± 0.49
Balsamorhiza sagittata	0.50 ± 0.50	0.33 ± 0.33
Convolvulus arvensis	2.58 ± 2.48	2.16 ± 1.51
Iris germanica	0.66 ± 0.47	0.33 ± 0.21
Medicago sativa	0.50 ± 0.50	0.16 ± 0.16
Shrubs		
Artemisia abrotanum	1.08 ± 0.61	0.66 ± 0.33
Litter	22.91 ± 7.91	
Bare ground	50.41 ± 8.17	
Rock	16.75 ± 4.58	

[1]All species are listed for the forage kochia and grass sites. For the sainfoin and Palmer penstemon sites, species with mean cover class values less than 0.25 were omitted. For the sainfoin site this omitted *Bromus japonicus*, *Secale cereale*, and *Sitanion hystrix*. For the Palmer penstemon site this omitted *Ranunculus testiculatus* and *Tragopogon dubius*.

[2]For common names see appendix A.

[3]According to Utah Department of Transportation records, the following seed mixture was planted along the roadcut in 1979 after the lower Ephraim Canyon road was upgraded and paved: Fairway wheatgrass (*Agropyron cristatum*—7½ lb/acre), Sodar wheatgrass (*Agropyron riparium*—7½ lb/acre), and sainfoin (*Onobrychis viciifolia*—4 lb/acre).

[4]Palmer penstemon seeded in 1979. The forbs bur buttercup (*Ranunculus testiculatus*) and yellow salsify (*Tragopogon dubius*) were present in trace amounts only; their percent cover and density are not given.

[5]Forage kochia was seeded in 1979.

[6]Unburned portion of site.

[7]Burned portion of site. Fire occurred in 1983 or 1984.

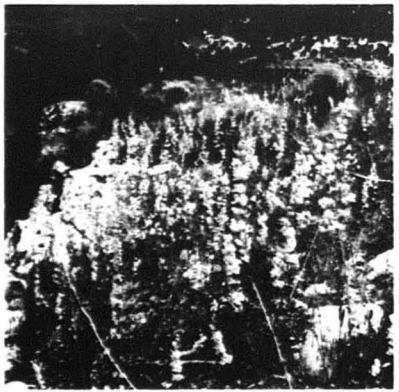


Figure 15—Palmer penstemon seeded alongside Ephraim Canyon Road, Sanpete County, UT.

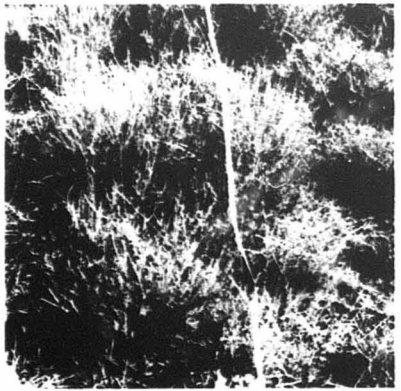


Figure 17—North-facing slope of Ephraim Canyon roadfill where forage kochia was originally planted, Sanpete County, UT.

Figure 16—Mixture of species along Palmer penstemon transect, Sanpete County, UT.

introduced grasses, jointed goatgrass (22.80 ± 7.90), and Japanese chess (13.10 ± 5.07). They were followed by:

field bindweed (9.60 ± 3.07)
bulbous bluegrass (*Poa bulbosa*) (5.90 ± 2.46)
cheatgrass (4.20 ± 1.71)
curlycup gumweed (3.40 ± 1.05)
bottlebrush squirreltail (*Sitanion hystrix*) (1.70 ± 0.55).

Penstemon was next with a density of 1.30 ± 0.49. Seven other species had lower mean density values (table 8 and appendix A).

When in bloom, Palmer penstemon is an attractive addition to the roadside vegetation (fig. 15). The evergreen, persistent basal leaves are readily eaten by deer and rabbits in the winter.

Considerably more bare ground, especially rock, was exposed at this site than at the sainfoin site. Much less ground was covered by litter (table 8).

Forage Kochia Site—This site near the mouth of Ephraim Canyon was seeded with forage kochia (*Kochia prostrata*) in 1979. The original seeding was planted along the slope of the roadfill on the north side of the county road (fig. 17). Forage kochia spread east from there and north about 28 m (92 ft). A wildfire burned a portion of the site in 1983 or 1984. The soil type is Sanpete stony fine sandy loam. The slope is about 7 percent, the aspect 300 degrees, and the mean annual precipitation

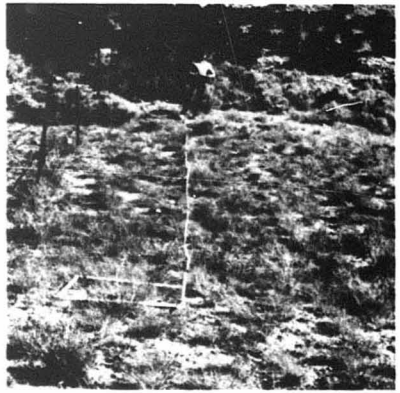


Figure 18—Transect through a portion of the forage kochia site that was burned in 1983 or 1984, Sanpete County, UT.

297 mm (11.7 in) (table 1). Forage kochia is a subshrub, or shrub with a woody base and herbaceous branches, native to the arid and semiarid regions of central Eurasia. Our material for this site was from the accession (sampled population) that became the cultivar 'Immigrant', widely adapted in the Western United States (Stevens and others 1985).

Transects were placed in adjacent burned (fig. 18) and unburned areas. The quadrats on the burned site were spaced at 5-m intervals. Quadrats on the unburned site were at 6-m intervals. At both sites the transect was laid from the top of the seeded slope north through the main area of the plants' spread.

Before road construction and the fire, this area was dominated by Wyoming big sagebrush, threadleaf rubber rabbitbrush (*Chrysothamnus nauseosus* ssp. *consimilis*), hairy low rabbitbrush (*C. viscidiflorus* ssp. *puberulus*), Utah juniper (*Juniperus osteosperma*), and gray horsebrush (*Tetradymia canescens*). Forage kochia, crested wheatgrass, and bulbous bluegrass did not appear to be materially affected by the fire. After the fire, jointed goatgrass, Wyoming big sagebrush, threadleaf rubber and hairy low rabbitbrushes, sheep fescue (*Festuca ovina*), Utah juniper, Indian ricegrass (*Oryzopsis hymenoides*), and gray horsebrush became less abundant or were wiped out. Cheatgrass, bindweed, storksbill (*Erodium cicutarium*), curlycup gumweed, broom snakeweed (*Gutierrezia sarothrae*), sainfoin, bur buttercup (*Ranunculus testiculatus*), bottlebrush squirreltail, and scarlet globemallow (*Sphaeralcea coccinea*) populations increased (McArthur and others 1990).

Forage kochia survived the fire and is maintaining a vigorous population. Some mature plants apparently died, but many survived. Recruitment has been successful (table 8) (McArthur and others 1990). The intensity, season, or other characteristics of the fire are not known.

Grass Sites—Various grasses were direct seeded along the roadcuts in Ephraim Canyon (fig. 19).

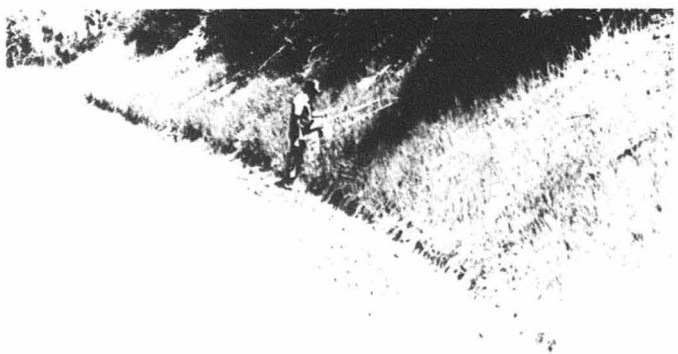


Figure 19—Grasses direct seeded on county road roadcuts, Ephraim Canyon, Sanpete County, UT.

Unfortunately, no record is available of what was planted or when. This obviously limits analysis. Four principal plantings are between 2,207 and 2,402 m (7,240 and 7,880 ft) elevation. Annual precipitation averages from about 405 to 480 mm (16 to 19 in) depending on elevation. Mollisol soils are dominant with Fontreen, Lizzant, Mower, Lundy, Skylick, Montenson, and Tingey series present. The slope of the cuts varied from 50 to 91 percent and their aspects from 170 to 320 degrees (table 1).

Smooth brome was the only grass found in quadrats at all four sites (fig. 20). It had an average mean cover of 9.33 percent (cover class 3) and average mean density of 29.52 (table 9). Density was determined by counting the number of culms. Although slender wheatgrass (*Agropyron trachycaulum*) was present at only three sites, it had an average mean cover of 18.89 percent (cover class 3) and density of 40.81 (fig. 21). It was the most abundant grass at these three sites. It also had the highest percent cover and density rating overall (table 9). Bluebunch wheatgrass (*Agropyron spicatum*) was the only other grass present in at least three sites (fig. 22). Its percent cover (3.04, cover class 2) and density (6.99) are considerably lower than for smooth brome or for slender wheatgrass (table 9). Pubescent wheatgrass (*Agropyron trichophorum*) was present only at the red cedar site (fig. 23 and table 9). It was the most significant species there with an average mean cover class of 16.25 (cover class 3) and average mean density of 108.16. This density was the highest recorded for any of the species at the four sites (table 9).

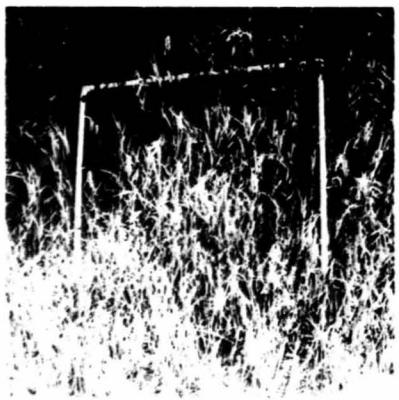


Figure 20—Quadrat along transect on grass site A, roadcut, Ephraim Canyon Road, showing only smooth brome (cover class 5) and thickleaf peavine (*Lathyrus lanszwertii*) (cover class 3), Sanpete County, UT.

Smooth brome and pubescent wheatgrass are both Eurasian introductions, whereas slender wheatgrass and beardless bluebunch wheatgrass are native to Western North America. Each species has an excellent record for reclamation in the Intermountain area (McArthur 1988; Wasser 1982).

Grasses were the most abundant and significant species on roadcuts at these four sites. The eleven forb species (six native and five introduced) and the three shrub species (two native and one introduced) were scattered and sparse (table 9 and appendix A).

Timber poisonvetch (*Astragalus convallarius*) was the only nongrass species present at all four sites. It averaged less than one plant per quadrat (average mean density = 0.48). Field bindweed, present at three sites, was the only nongrass species that averaged one or more (1.22) plants per quadrat (table 9).

Table 10 compares the mean cover class of litter, bare ground, and rock for transects at the Ephraim Canyon sites. The grass sites averaged second to the sainfoin site in litter, yet had the most bare ground exposed. This is probably due to the steepness of the cuts where the grasses were seeded.

Snowberry Site—Mountain snowberry bareroot transplants were planted in a row near the base of a north-facing roadcut in Ephraim Canyon in 1975. The cut was 56 m (184 ft) long. Except for snowberry, it was essentially bare in 1984 (fig. 24). The area is located at an elevation of 1,951 m (6,400 ft) just above the Palmer penstemon site. The soil type is Fontreen very cobbly loam. Annual precipitation averages 300 to 360 mm (12 to 14 in) (table 1). Mountain snowberry is a native, low-growing shrub that is easily transplanted on raw and severe sites (Plummer 1977).

Sixty-eight bareroot snowberry transplants indigenous to the site were planted nearby in the early spring of 1975. Unfortunately, this entire planting was destroyed in 1988 when the county road was widened.

The plants were individually evaluated in 1987, before the road work. Fifty-seven percent (39 plants) had survived and grown into an attractive soil-stabilizing hedge on a relatively barren cut. Their average mean crown was 104.9 ± 6.43 cm (41.3 ± 2.53 in) with an average mean height of 40.6 ± 2.58 cm (6.0 ± 1.02 in), and a mean average yield of new biomass (current year's growth) of 95.5 ± 10.3 g (3.4 ± 0.4 oz).

Oldman Wormwood Sites—In the early springs of the mid-1970's, oldman wormwood cuttings were

Table 9—Species density and cover class values from roadcut plantings of grass species along the Ephraim Canyon Road

Species[1]	Cover class (mean)				Weighted average		Density (mean)				Weighted average	
	Site BS[2]	Site PE	Site PW	Site RC	For sites present in[3]	For all four sites[4]	Site BS	Site PE	Site PW	Site RC	For sites present in	For all four sites
Grasses												
Agropyron intermedium	—	—	—	2.50	2.50	0.09	—	—	—	2.00	2.00	0.07
A. repens	—	—	—	2.50	2.50	0.09	—	—	—	16.00	16.00	0.59
A. spicatum	3.07	11.25	1.55	—	3.90	3.04	10.42	23.25	2.30	—	8.89	6.99
A. trachycaulum	25.71	16.87	26.25	—	24.28	18.89	45.14	32.00	65.80	—	52.48	40.81
A. trichophorum	—	—	—	16.25	16.25	0.60	—	—	—	108.16	108.16	4.01
Bromus inermis	13.64	3.75	6.35	13.00	9.33	9.33	46.71	15.50	13.00	46.33	29.52	29.52
Dactylis glomerata	0.42	—	—	—	0.42	0.12	0.14	—	—	—	0.14	0.01
Phleum pratense	—	0.12	—	—	0.12	[5]0	—	0.25	—	—	0.25	0.01
Poa pratensis	4.28	—	0.30	—	1.94	1.22	10.00	—	0.90	—	4.65	2.93
Forbs												
Astragalus species	—	—	—	0.08	0.08	[5]0	—	—	—	0.16	0.16	[5]0
A. cicer	0.42	—	—	—	0.42	0.02	0	—	—	—	0	0
A. convallarius	2.14	0.75	0.30	0.58	1.08	1.08	0.42	1.25	0.10	0.66	0.48	0.48
Balsamorhiza sagittata	2.14	—	—	0.50	1.38	0.67	0.14	—	—	0.33	0.23	0.11
Convolvulus arvensis	0.07	—	1.55	2.58	1.37	1.28	0	—	1.50	2.16	1.22	1.04
Cynoglossum officinale	—	—	1.50	—	1.50	0.06	—	—	—	0.70	0.70	0.03
Erigeron species	0.42	0.12	—	—	0.31	0.13	0.14	0.25	—	—	0.18	0.07
Iris germanica	—	—	1.50	0.66	1.19	0.70	—	—	0.20	0.33	0.25	0.15
Lathyrus lanszwertii	2.14	—	—	—	2.14	0.08	1.28	—	—	—	1.28	0.05
Medicago sativa	—	—	1.50	0.50	1.13	0.67	—	—	0.30	0.16	0.25	0.15
Stellaria jamesiana	0.07	—	—	—	0.07	[5]0	0.86	—	—	—	0.86	0.03
Shrubs												
Artemisia abrotanum	0.07	—	—	1.08	0.54	0.26	0.85	—	—	0.66	0.76	0.37
Quercus gambelii	—	—	3.75	—	3.75	0.14	—	—	3.75	—	3.75	0.14
Rosa woodsii	—	3.75	3.50	—	3.57	1.85	—	1.00	0.90	—	0.50	0.26
Litter	48.21	26.25	39.55	22.91	36.13	36.13	—	—	—	—	—	—
Bare ground	16.28	56.25	38.25	50.41	37.92	37.92	—	—	—	—	—	—
Rock	8.85	15.00	12.60	16.75	12.91	12.91	—	—	—	—	—	—

[1]For common names see appendix A.
[2]BS = below slide, PE = ponderosa east, PW = ponderosa west, and RC = red cedar.
[3]Weighted average for sites present was determined by multiplying mean cover class for each site by the number of quadrats read at each site. These were added together and divided by the total number of quadrats read for each of the sites where the species was found.
[4]Weighted average for all four grass sites was determined as described above, except the final sum was divided by 27, the total number of quadrats for all four sites.
[5]Although some plants were present, the weighted average for all four sites was <0.01.

planted along (fig. 25) and over (fig. 26) several roadcuts adjacent to the county road in Ephraim Canyon at an elevation of 2,024 m (6,640 ft). Precipitation here averages about 380 mm (15 in). This site is on the same Fontreen very cobbly loam soil type as the snowberry site (table 1).

The surviving plants were counted on June 23, 1987. Of the 920 cuttings estimated to have been planted, 391 (44.5 percent) had established and were growing well in 1987. The major portion of these plantings were destroyed in 1988 when the county road was widened.

Salina Canyon Area

The plantings in Salina Canyon are located along Interstate 70 and its western approaches, including U.S. Highway 89 in southern Sanpete and northern Sevier Counties. Interstate 70 was constructed during the late 1960's and early 1970's. Salina Canyon separates two of Utah's high plateaus, the Wasatch Plateau on the north and the Fish Lake Plateau on the south (Fenneman 1931). Located at the mouth of the canyon, the town of Salina has an elevation of 1,570 m (5,148 ft). Interstate 70 crests at about 2,410 m (7,900 ft) at Emigrant or Wasatch Pass. Precipation increases from the 253 mm (9.95 in) annual mean at Salina to about 508 mm (20.0 in) at the Interstate 70 crest (Richardson and others 1981; Stevens and others 1983). The native vegetation communities change from salt desert shrub (principally shadscale) near Salina to pinyon-juniper, mountain brush, and finally to curlleaf mountain-mahogany (*Cerocarpus ledifolius*) at the crest. There are also grassy meadows and riparian areas along the way. The soils, often alkaline, clay

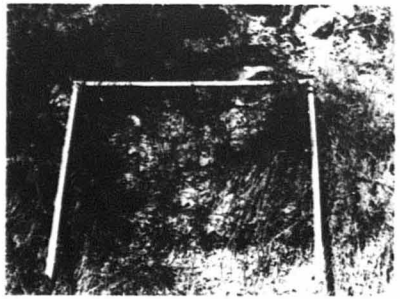


Figure 21—Quadrat along transect on grass site C, roadcut, Ephraim Canyon Road, showing slender wheatgrass (cover class 3) and smooth brome (cover class 1), Sanpete County, UT.

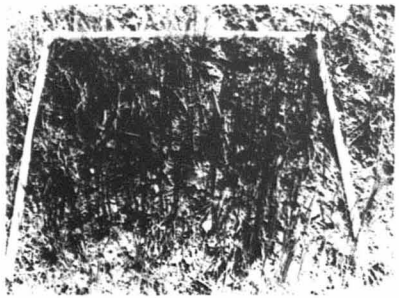


Figure 22—Quadrat along transect on grass site B, roadcut, Ephraim Canyon Road, showing beardless bluebunch wheatgrass (cover class 3), slender wheatgrass (cover class 2) and fleabane daisy (*Erigeron* spp.) (cover class 1), Sanpete County, UT.

Figure 23—Quadrat along transect on grass site D, roadcut, Ephraim Canyon Road, showing pubescent wheatgrass (cover class 4) and smooth brome (cover class 3), Sanpete County, UT.

Table 10—Comparison of the mean cover classes for litter, bare ground, and rock at the Ephraim Canyon sites including mean ($\bar{x}$) values and standard error (se)

Cover types	Sainfoin ($\bar{x} \pm$ se)	Penstemon ($\bar{x} \pm$ se)	Kochia		Grass ($\bar{x} \pm$ se)
			Burned ($\bar{x} \pm$ se)	Nonburned ($\bar{x} \pm$ se)	
Litter	50.00 ± 6.41	12.35 ± 1.77	24.00 ± 5.51	33.50 ± 8.82	36.13 ± 6.40
Bare ground	3.35 ± 1.96	12.15 ± 3.46	33.00 ± 4.50	19.70 ±11.03	37.92 ± 7.86
Rock	18.70 ± 5.37	65.50 ± 6.14	7.80 ± 2.93	6.80 ± 3.37	12.91 ± 4.35

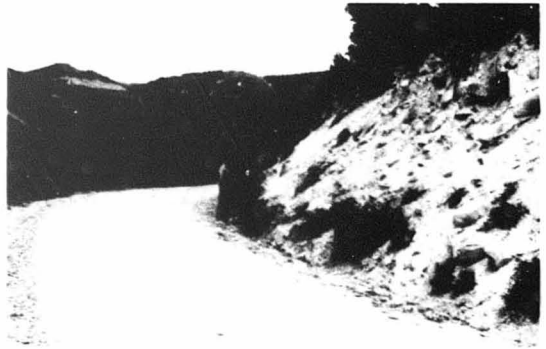


Figure 24—Transplanted mountain snowberry growing near base of Ephraim Canyon Road, Sanpete County, UT.

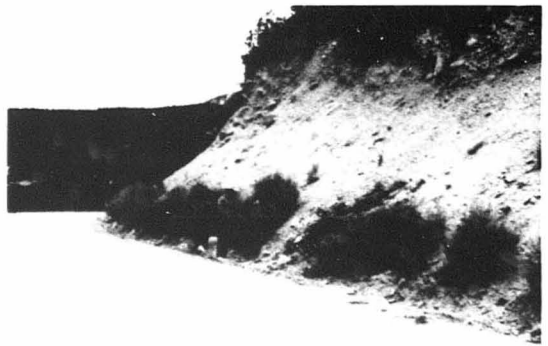


Figure 25—Oldman wormwood cuttings growing along base of steep, barren roadcut along Ephraim Canyon Road (note soil building up behind plants). These were planted in 1975. Sanpete County, UT.

Figure 26—Oldman wormwood cuttings planted over face of roadcut, Ephraim Canyon Road, Sanpete County, UT. These were planted in 1986.

loams, are mostly mollisols and aridisols complexly interwoven among many series including Ellett, Freece, Lizzant, Sanpete, and Sigurd (Hutchings and Murphy 1981; Parslow 1988).

The soil characteristics of areas disturbed by the highway generally were not different (by paired *t*-test statistic, Woolf 1968) from adjacent undisturbed soils (table 11). Sites and pairs varied considerably, but not in any consistent way. Only in the case of potassium was there a consistent significant ($p < 0.05$) difference between soils along the highway cut and undisturbed soils; highway cut soils had on average 70 percent more potassium than undisturbed soils (190.4 vs. 112.5 parts per million, data not shown). At the Interstate 70 mile 60 site the roadside values were 5.4, 0.34, and 17.6 for cation exchange capacity, electrical conductivity, and sodium adsorption ratio, respectively. The corresponding values for undisturbed soils at paired sites were 45.7, 19.0, and 236.0 (data not shown). At the mile 77 site, organic matter was over twice as high for the highway right-of-way as it was for the paired undisturbed site (1.65 vs. 0.70 percent). At the mile 77 site and the Sterling site, the manganese values were much higher for the paired undisturbed sites than for the right-of-way (11.26 and 20.78 vs. 2.20 and 4.90 parts per million). It is difficult to evaluate soil test values in relationship to soil nutrient availability for wildland plant species. Soil test information has not been well correlated with nutrient uptake in these plants. However, plant growth was almost always superior on roadcuts where a reasonable depth of true weathered soil was available, compared to roadcuts where the substrate was relatively unweathered subsoil and geological regolith (rock that forms the earth's mantle).

South-Central Utah Forage Kochia Plantings

Forage kochia was broadcast seeded by hand in Sanpete and Sevier County roadcuts during the mid-1970's (tables 1 and 12). These plantings ranged from valley floor sites along U.S. 89 to more upland sites along the county road near the mouth of Ephraim Canyon (see Forage Kochia Site under the Ephraim Canyon discussion, p. 20) and along Interstate 70 in Salina Canyon. Forage kochia performance at these sites is detailed in our companion papers—McArthur and others (1990); Stevens and McArthur (1990). Study sites were surface seeded, mostly with the accession that became 'Immigrant' forage kochia. Some other accessions, including both subspecies of forage kochia, were also seeded. 'Immigrant' is a selection from PI (Plant Introduction) line 314929 of *Kochia prostrata* ssp. *virescens* (Stevens and others 1985). Seeds were broadcast seeded and raked lightly into the seedbed during the fall.

These are mostly semiarid sites with an average annual precipitation ranging from less than 200 to more than 500 mm (8 to 20 in). The slope varies from 0 to 64 percent with elevation ranging from 1,570 to 2,232 m (5,150 to 7,320 ft). The soils are generally mollisols, but also include aridisols and entisols. Specific soil types are the Genola-Woodrow-Quaker, Arapien-Sanpete-Lisade, Sanpete-Sigurd, Poganeab-Shumway-Chipman,

Table 11—Characteristics of soils in Salina Canyon and adjacent lowlands[1] including mean ($\bar{x}$) values and standard error (se)

Values	Characteristic[2]					
	Percent clay	Percent silt	Percent sand	pH	CEC	SAR
$\bar{x} \pm$ se	35.2 ± 3.2	31.3 ± 2.7	33.6 ± 4.6	7.9 ± 0.1	24.2 ± 6.8	39.7 ± 20.2
Range	13.4 – 43.4	16.2 – 50.3	15.4 – 70.4	7.4 – 8.4	5.4 – 79.4	4.6 – 236.0
Significance[3]	NS	NS	NS	NS	NS	NS
	EC	OM	–0.3 Bar	–15 Bar AWHC	NO_3	
$\bar{x} \pm$ se	2.41 ± 1.52	0.79 ± 0.11	0.16 ± 0.02	0.098 ± 0.017	3.62 ± 0.33	
Range	0.34 – 19.00	0.29 – 1.65	0.05 – 0.32	0.017 – 0.213	2.48 – 6.56	
Significance[3]	NS	NS	NS	NS	NS	
	Phosphorus	Sodium	Zinc	Iron	Manganese	Copper
$\bar{x} \pm$ se	2.51 ± 0.58	160.8 ± 22.0	0.58 ± 0.13	24.5 ± 5.3	5.9 ± 1.6	0.64 ± 0.07
Range	0.24 – 6.40	54.4 – 288.0	0.26 – 1.86	3.2 – 39.5	1.7 – 20.8	0.38 – 1.08
Significance[3]	NS	*	NS	NS	NS	NS

[1]Since road cuts and undisturbed sites were not generally different, the means were combined in this table.
[2]CEC = cation exchange capacity; SAR = sodium adsorption ratio; EC = electrical conductivity; OM = organic matter; Bar = bars of pressure; AWHC = average water-holding capacity.
[3]NS = not significantly different by paired *t*-test; * = significantly different at $p < 0.05$.

Table 12—Locations and descriptions of study sites for the roadside planting of forage kochia in central Utah (after McArthur and others 1990)

Site	Location and elevation	Description	Transect number	Quadrat number
Ephraim Canyon, Sanpete County	Mouth of canyon along Ephraim-Orangeville Road, 1,780 m (5,840 ft)	Roadside, burned and unburned	2	10
Nine Mile Reservoir, Sanpete County	Along U.S. Highway 89 1,645 m (5,400 ft)	Roadcut, natural	2	15
North of Sterling, Sanpete County	Along U.S. Highway 89 1, 675 m (5,500 ft)	Roadcut, natural pasture	3	25
Redmond cut, Sevier County	Along U.S. Highway 89 1,570 m (5,150 ft)	Roadcut, crest	3	20
Redmond junction, Sanpete County	Along U.S. Highway 89 1,575 m (5,160 ft)	Roadside	1	10
Salina Canyon, Sevier County (Salina Canyon mouth)	Along I-70, mouth of canyon 1,615 m (5,300 ft)	Roadcut, natural	2	15
Salina Canyon, Sevier County (cut 19)	Along I-70, milepost 57.8, north side, 1,730 m (5, 670 ft)	Roadcut	2	10
Salina Canyon, Sevier County (cut 20)	Along I-70, milepost 58, north side 1,725 m (5,660 ft).	Roadcut, natural (*Kochia prostrata* and *Ceratoides lanata* plantings)	3	35
Salina Canyon, Sevier County (cut 1)	Along I-70, milepost 58.5, south side 1,735 m (5,690 ft)	Roadcut, natural (*Kochia prostrata* and *Ceratoides lanata* plantings).	2	20
Salina Canyon, Sevier County (cut 17)	Along I-70, milepost 60, north side 1,750 m (5, 750 ft)	Roadcut	4	25
Salina Canyon, Sevier County (cut 7)	Along I-70, milepost 74, south side 2,220 m (7,220 ft)	Roadcut	2	10
Salina Canyon, Sevier County (cut 10)	Along I-70, milepost 76, south side 2,230 m (7,320 ft)	Roadcut	1	10

Fontreen-Lodar-Borvant, Lissant-Mower-Lundy, and Skylick-Mortenson-Tingey associations (Hutchings and Murphy 1981; Parslow 1988; Swenson and others 1981).

'Immigrant' and other lines of forage kochia performed well in the highway right-of-way plantings (fig. 27). Forage kochia grows well in association with a variety of plants, including native and introduced, annual and perennial, and herbaceous and woody. Commonly associated with forage kochia on these quadrats (appendix A) (McArthur and others 1990) were:

Introduced annual grass
- cheatgrass

Introduced perennial grasses
- fairway crested wheatgrass
- intermediate wheatgrass
- orchard grass (*Dactylis glomerata*)

Native perennial grasses
- western wheatgrass (*Agropyron smithii*)
- bluebunch wheatgrass
- Indian ricegrass
- bottlebrush squirreltail

Introduced annual forbs
- storksbill
- African mustard (*Malcolmia africana*)
- yellow sweetclover
- bur buttercup

Figure 27—Seeded 'Immigrant' forage kochia in Salina Canyon, Sevier County, UT, at a site near the canyon mouth along Interstate 70. The light plants in the background are cheatgrass. Although forage kochia was not seeded across the fence (arrow), it is invading there.

Russian thistle (*Salsola iberica*)
goatsbeard (*Tragopogon dubius*)
Native annual forb
prickly lettuce (*Lactuca seriola*)
Perennial native forbs
sulphur buckwheat (*Eriogonum umbellatum*)
curlycup gumweed (*Grindelia squarrosa*)
Native shrubs
big sagebrush
fourwing saltbush (*Atriplex canescens*)
shadscale saltbush (*A. confertifolia*)
winterfat (*Ceratoides lanata*)
rubber rabbitbrush
low rabbitbrush (*C. viscidiflorus*)
broom snakeweed

Other species associated with forage kochia less commonly on these quadrats (appendix A; McArthur and others 1990) were:

Introduced annual grasses
jointed goatgrass
annual rye (*Secale cereale*)
Introduced perennial grasses
tall wheatgrass (*Agropyron elongatum*)
quackgrass (*A. repens*)
smooth brome
sheep fescue (*Festuca ovina*)
bulbous bluegrass
Native perennial grasses
basin wildrye (*Elymus cinereus*)
galleta (*Hilaria jamesii*)
Nevada bluegrass (*Poa nevadensis*)
Sandberg bluegrass (*P. secunda*)
spike dropseed (*Sporobolus contractus*)
needle-and-thread (*Stipa comata*)
Introduced annual forbs
tansy mustard (*Descurainia sophia*)
halogeton (*Halogeton glomeratus*)
summer cypress (*Kochia scoparia*)
clasping-leaf pepperweed (*Lepidium perfoliatum*)
Native annual forbs
Cryptantha (*Cryptantha* spp.)
Watson buckwheat (*Eriogonum hookeri*)
gilia (*Gilia* spp.)
western stickseed (*Lappula occidentalis*)
little polecat (*Microsteris gracilis*)
evening primrose (*Oenothera* spp.)
Introduced perennial forbs
field bindweed
alfalfa (*Medicago sativa*)
sainfoin
small burnet (*Sanguisorba minor*)
Perennial native forbs
sandwort (*Arenaria* spp.)
milkvetch (*Astragalus* spp.)
Kentrophyta milkvetch (*Astragalus kentrophyta*)
Sego lily (*Calochortus nuttallii*)
shortstem buckwheat (*Eriogonum brevicaule*)
ballhead gilia (*Gilia congesta*)
Utah sweetvetch (*Hedysarum boreale*)
poverty sumpweed
carpet phlox (*Phlox hoodii*)
longleaf phlox (*P. longifolia*)
twinpod (*Physaria* spp.)
scarlet globemallow
gooseberryleaf globemallow (*Sphaeralcea grossulariaefolia*)
Native shrubs
black sagebrush
pygmy sagebrush (*Artemisia pygmaea*)
Nevada ephedra (*Ephedra nevadensis*)
green ephedra (*E. viridis*)
gray molley (*Kochia americana*)
pricklypear (*Opuntia* spp.)
black greasewood (*Sarcobatus vermiculatus*)
gray horsebrush (*Tetradymia canescens*)
spiny horsebrush (*T. spinosa*)

Forage kochia had the highest mean cover class value of the 25 species that occurred in at least three of the 12 sites evaluated (McArthur and others 1990). Furthermore, its density value was exceeded only by four annuals: cheatgrass, storksbill, bur buttercup, and Russian thistle. It is well adapted to these study sites, since it succeeded in the areas where it was planted, and it grew and persisted both on the disturbed roadsides and on undisturbed sites (McArthur and others 1990) (table 12 and fig. 28). It competes well with other species that do well in disturbed areas, such as cheatgrass and halogeton, and with all other species at our study sites (McArthur and others 1990; Stevens and McArthur 1990).

The seedlings, young plants, and mature forage kochia plants found on the study sites demonstrate that forage kochia is sustaining itself in these plant communities (fig. 29). Aside from annual species, seedlings from only two other species were found in the quadrats: black sagebrush and forage kochia. Forage kochia had seedlings at all 12 sites and in three-fourths of the transects that included mature forage kochia plants. Black sagebrush had seedlings at just one site. Forage kochia seedlings had an average cover class value of 1.5 ± 0.6 (values ranged from 1 to 3) and a density of 18.2 ± 21.5 (values ranged from 0.2 to 72.8). Forage kochia plants have become established up to 100 m (328 ft) from original seeding sites in natural and pasture plant communities, as well as the severely disturbed highway right-of-way sites (figs. 27-30) (McArthur and others 1990). Our observations suggest that forage kochia will be an integral part of the plant communities at these study sites for the foreseeable future. Forage kochia has demonstrated its value as a revegetation species on harsh sites in these studies and others (Monsen and Turnipseed 1990; Pendleton and others 1992).

Figure 28—Transect and quadrat on forage kochia seeding, roadcut 17, Salina Canyon, Sevier County, UT.

Figure 29—Forage kochia showing all stages of development, from seedlings and young plants to mature plants, on roadcut 20, Salina Canyon, Sevier County, UT.

Fourwing Saltbush Seedings

Fourwing saltbush (*Atriplex canescens*) was broadcast seeded on three roadcuts in or near the Salina Interstate 70 interchange (fig. 31) in the mid-1970's: South Salina, Interstate 70 on-ramp, and Interstate 70 off-ramp (table 1). These semiarid sites have an average annual precipitation of 255 to 280 mm (10 to 11.5 in). The elevation ranges from 1,585 to 1,616 m (5,200 to 5,300 ft) with slopes ranging from 26 to 47 percent. The general soil type is a mollisol of the Badland-Skumpah association (Hutchings and Murphy 1981; Swenson and others 1981) (table 1). Fourwing saltbush is a valuable native reclamation plant (Blauer and others 1976; McArthur and others 1983, 1984). The accession that became the wildland cultivar 'Rincon' (McArthur and others 1984),

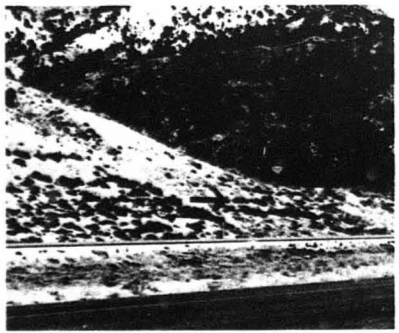


Figure 30—Forage kochia spreading eastward (arrow) from area of original seeding on roadcut 20, Salina Canyon, Sevier County, UT.

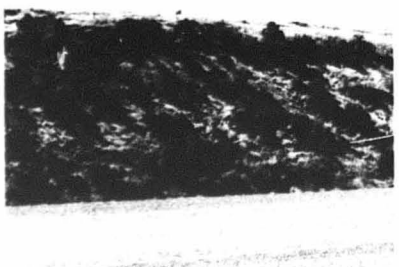


Figure 31—Fourwing saltbrush growing on roadcut near the Salina Interstate 70 interchange, Sevier County, UT.

along with other accessions, was seeded at the study sites.

In addition to seeding fourwing saltbush, several other species were transplanted at South Salina and the Interstate 70 on-ramp roadcuts. Except for German iris (*Iris germanica*) at the on-ramp site, many of these transplants failed. We were unable to determine what was planted where. Thus, other transplanted species could not be evaluated. The iris, once established, persisted and showed recruitment. Only 43 survived out of 500 planted in 1976, but there were 76 plants in 1986, an increase of 177 percent. German iris is a perennial herb ordinarily planted as an ornamental flower. It is native to the Mediterranean area, but has been widely planted and naturalized worldwide (Bailey Hortorium Staff 1976). It has an extensive root system and is surprisingly persistent in arid sites. It was a favorite of the late Intermountain Research Station scientist A. Perry Plummer, who planted it on roadcuts and other disturbed areas.

Two transects of five quadrats were run at each of the three sites. Fourwing saltbush established well at all three sites. It had a weighted average percent cover of 15.1 percent, second only to cheatgrass, 19.9 percent. These species were followed by cryptogamic plants with a weighted average percent cover of 12.9 percent and shadscale saltbush, 4.4 percent). Shadscale saltbush, a common, native shrub, is an important component of natural vegetation in the study area. However, it is often difficult to seed (Blauer and others 1976). It was seeded along with fourwing saltbush in a composite seed mixture at the on-ramp site where it had a greater density and percent cover than fourwing saltbush (3.6 and 12.8 vs. 2.5 and 10.4). The weighted average percent cover for all other plants was less than 4 percent (table 13).

Cryptogams were more abundant on slopes with northern exposures. These plants had a collective mean percent cover at the on-ramp site (aspect = 330 degrees) of 29.8 percent, at the South Salina site (aspect = 25 degrees) of 9.0 percent, and at the off-ramp site (aspect = 175 degrees) of 0 percent. Thus, the cryptogams were absent on the cut with the southern exposure (off-ramp) and relatively abundant on the two slopes with northern exposures (on-ramp and South Salina). The cryptogams at the on-ramp site had the highest mean percent cover (29.8) of any plant at any of the three sites with the exception of cheatgrass at South Salina (table 13).

Three groups of plants were present at all three sites: an introduced annual grass (cheatgrass), an introduced annual forb (African mustard), and a native shrub (fourwing saltbush). Fourwing saltbush was planted at these roadcuts, but is a native plant characteristic of such sites. Cheatgrass and fourwing saltbush were also present at each of the six transects. Cheatgrass was in 28 of the 30 quadrats, fourwing saltbush was in 21 quadrats, and African mustard was in 14. Although the cryptogams were missing from the two off-ramp transects, they were in 16 quadrats. The rest of the species were found at no more than nine quadrats and at no more than three transects (table 13).

Table 13—Species density and cover class values from fourwing saltbush plantings on three roadcuts near or on the Salina Interstate 70 interchange

Species[1]	Origin[2]	Presence in: Number of sites	Number of transects[3]	Number of quadrats[4]	Cover class: Sites: South Salina	On-ramp	Off-ramp	For sites present in[5]	For all three sites[6]	Density: Sites: South Salina	On-ramp	Off-ramp	For sites present in[5]	For all three sites[6]
					------- *Mean* -----			*Weighted average*		------ *Mean* -----			*Weighted average*	
Annual grass														
Bromus tectorum	I	3	6	28	50.00	8.05	1.70	19.92	19.92	585.50	141.50	18.40	249.50	249.50
Perennial grasses														
Agropyron cristatum[7]	I	2	3	7	—	10.50	0.30	5.40	3.60	—	1.90	0.10	1.00	0.70
Oryzopsis hymenoides	N	1	2	3	—	0.65	—	0.65	0.22	—	0.20	—	0.20	0.07
Stipa comata	N	1	2	2	—	0.10	—	0.10	0.03	—	0.10	—	0.10	0.03
Annual forbs														
Alyssum alyssoides	I	1	1	1	0.30	—	—	0.30	0.10	12.00	—	—	12.00	4.00
Descurainia sophia	I	2	3	3	0.05	—	0.10	0.08	0.05	0.10	—	0.40	0.25	0.17
Halogeton glomeratus	I	1	2	2	—	—	1.80	1.80	0.60	—	—	1.90	1.90	0.63
Kochia scoparia	I	1	1	1	0.05	—	—	0.05	0.17	0.2	—	—	0.20	0.07
Lappula occidentalis var. *cupulata*	N	1	2	3	—	—	0.40	0.40	0.13	—	—	0.80	0.80	0.27
Malcolmia africana	I	3	5	14	0.30	2.40	4.85	2.52	2.52	1.50	30.50	4.70	12.23	12.23
Ranunculus testiculatus	I	1	2	4	—	0.45	—	0.45	0.15	—	9.10	—	9.10	3.03
Salsola iberica (pestifer)	I	1	1	1	—	—	0.05	0.05	0.17	—	—	0.20	0.20	0.07
Biennial forb														
Lactuca serriola[8]	I	1	2	4	—	—	0.20	0.20	0.07	—	—	0.50	0.50	0.17
Shrubs														
Artemisia tridentata ssp. *tridentata*	N	2	2	3	3.75	7.75	—	5.75	3.83	0.10	0.20	—	0.15	0.10
Atriplex canescens	N	3	6	21	15.00	10.35	19.95	15.10	15.10	0.90	2.50	0.80	1.40	1.40
Atriplex confertifolia	N	2	3	9	—	12.80	0.30	6.55	4.36	—	3.60	0.10	1.85	1.23
Sarcobatus vermiculatus	N	2	2	2	3.75	0.50	—	2.13	1.42	0	0.10	—	0.05	0.03
Sarcobatus vermiculatus seedlings	N	2	1	1	0.10	—	—	0.05	0.03	1.80	—	—	1.80	0.60
Cryptogams	—	—	4	16	9.00	29.80	0.00	19.40	12.93	—	—	—	—	—
Litter	—	—	6	30	21.75	30.75	20.55	24.35	24.35	—	—	—	—	—
Bare ground	—	—	6	29	19.85	28.75	64.25	37.60	37.60	—	—	—	—	—
Rock	—	—	6	29	6.50	8.75	19.50	11.58	11.58	—	—	—	—	—

[1]For common names see appendix A.
[2]I = introduced, N = native, determined from Welsh and others (1987).
[3]Six transects were evaluated, two at each site.
[4]Thirty quadrats were read, 10 at each site.
[5]The weighted average for sites the plant was present in was determined by multiplying the mean cover class for each site by the number of quadrats read at each site. These were added together and divided by total number of quadrats read where the species was found.
[6]The weighted average for all three sites was determined as described above, except the final sum was divided by 30, the total number of quadrats.
[7]Includes *Agropyron desertorum*.
[8]This species may also be a winter annual.

Salina Canyon Winterfat Seedings

Winterfat was broadcast seeded on three roadcuts along Interstate 70 in Salina Canyon during the mid-1970's (figs. 32 and 33; Salina Canyon cuts 1, 18, and 20 of table 1). These semiarid sites have an average annual precipitation of about 305 mm (12 in). Elevation ranges from 1,726 to 1,738 m (5,660 to 5,700 ft), slope from 34 to 55 percent, and aspect from 5 to 165 degrees (table 1).

Winterfat does not spread extensively like forage kochia, but it is maintaining itself well. Winterfat is a native shrub valued for forage and for revegetation (Blauer and others 1976; McArthur 1988).

Winterfat was by far the dominant species at each of the three sites (fig. 33). It had a weighted average mean percent cover of 9.8 and density of 4.2. The only other species with a mean above 1.0 were kentrophyta milkvetch (3.0), shadscale saltbush (2.6), Indian ricegrass (2.0), intermediate wheatgrass (1.7), and sulfur wild buckwheat (*Eriogonum umbellatum*) (1.1). Furthermore, of the 15 species associated with winterfat at these three sites, none except winterfat was found at each site. Winterfat was found along all four transects and in 16 of the 20 quadrats (table14 and appendix A). Shadscale, found in six quadrats, was the second most common species.

Figure 33—Winterfat growing where it was seeded on roadcut 20, Salina Canyon, Sevier County, UT. It is the dominant plant here.

Figure 32—Winterfat (light-colored plants, left) and forage kochia (dark-colored plants, center and right) growing on roadcut with southerly exposure in Salina Canyon, Sevier County, UT.

Salina Canyon Trident Saltbush Seedings

Trident saltbush (*Atriplex gardneri* var. *tridentata*) was broadcast seeded on Interstate 70 roadcut (number 16) at the Gooseberry off-ramp, milepost 61 (table 1; fig. 34). This roadcut had a southerly exposure of 160 degrees with a slope of 31 percent. Elevation was 1,768 m (5,800 ft) with an annual average precipitation of about 310 mm (12.2 in) (table 1). Trident saltbush is a shrub that can tolerate high salt concentrations (>30,000 parts per million). It often spreads by root sprouts. Its area of natural distribution is the Bonneville Basin extending into eastern Utah and southwestern Wyoming (Hanson 1962; Stutz and others 1979).

Trident saltbush covered an area on the cut about 66 m (216 ft) long and 26 m (85 ft) wide. Two transects were run with five quadrats each. One transect ran the length of the seeding, while the second transect ran up the face of the slope and onto the crest (fig. 35). On the second transect, three quadrats were read along the face of the cut and two on the crest, where the saltbush had spread since the initial seeding. Since the crest wasn't as disturbed as the face, it had more natural vegetation (table 15).

Table 14—Species density and cover class values from winterfat plantings on three roadcuts along Interstate 70 in lower Salina Canyon

Species[1]	Origin[2]	Presence in: Number of sites	Number of transects[3]	Number of quadrats[4]	Cover class: Sites Cut 1	Sites Cut 18	Sites Cut 20	For sites present in[5]	For all three sites[6]	Density: Sites Cut 1	Sites Cut 18	Sites Cut 20	For sites present in[5]	For all three sites[6]
					----- Mean -----			Weighted average		----- Mean -----			Weighted average	
Annual grass														
Bromus tectorum	I	1	2	2	—	0.10	—	0.10	0.005	—	0.30	—	0.30	0.15
Perennial grasses														
Agropyron cristatum	I	2	2	4	0.30	0.30	—	0.30	0.23	1.00	0.10	—	0.40	0.30
Agropyron intermedium var. *intermedium*	I	2	2	3	3.00	1.80	—	2.20	1.65	4.40	0.00	—	4.40	1.10
Oryzopsis hymenoides	N	1	2	3	—	0.40	—	0.40	2.00	—	0.30	—	0.30	0.15
Sitanion hystrix	N	1	1	1	—	0.05	—	0.05	0.003	—	0.20	—	0.20	0.10
Annual forbs														
Malcolmia africana	I	1	1	1	—	—	0.60	0.60	0.15	—	—	2.20	2.20	0.50
Salsola iberica (pestifer)	I	1	1	2	—	—	0.20	0.20	0.05	—	—	1.60	1.60	0.40
Biennial forb														
Lactuca serriola[7]	I	1	1	1	—	—	0.10	0.10	0.005	—	—	0.20	0.20	0.10
Perennial forbs														
Astragalus kentrophyta	N	1	2	5	—	6.05	—	6.05	3.03	—	1.10	—	1.10	0.55
Eriogrnum umbellatum	N	2	3	5	0.60	1.90	—	1.47	1.10	0.20	0.90	—	0.73	0.55
Grindelia squarrosa[8]	N	1	1	1	—	1.50	—	1.50	0.75	—	0.10	—	0.10	0.005
Kochia americana	N	1	1	1	—	0.05	—	0.05	0.03	—	0.00	—	0.00	0.00
Shrubs														
Atriplex confertifolia	N	2	3	6	—	4.80	6.00	3.40	2.55	—	0.80	0.20	0.60	0.45
Ceratoides lanata	N	3	4	16	9.70	9.05	11.20	9.75	9.75	1.20	7.20	1.00	4.15	4.15
Kochia prostrata	I	2	2	3	3.10	—	0.60	1.85	0.93	2.80	—	0.40	1.07	0.80
Kochia prostrata seedlings	I	1	1	1	0.10	—	—	0.10	0.005	1.00	—	—	1.00	0.33
Litter					6.30	13.55	10.20	10.90	10.90					
Bare ground					66.50	64.25	62.00	64.25	64.25					
Rock					17.10	28.50	6.30	20.15	20.15					

[1]For common names see appendix A.
[2]I = introduced, N = native, determined from Welsh and others (1988).
[3]Four transects were run: one at cut 1, two at cut 18, and one at cut 20.
[4]Twenty quadrats were read, five for each transect.
[5]The weighted average for the sites the plant was present in was determined by multiplying the mean cover class for each site by the number of quadrats read at each site. These were added together and divided by the total number of quadrats where the species was found.
[6]The weighted average for all three sites was determined as described above, except the final sum was divided by 20, the total number of quadrats.
[7]This species may also be a winter annual.
[8]This species may also be a biennial.

Figure 34—Trident saltbrush growing where it was seeded on roadcut 16, Salina Canyon, Sevier County, UT.

Figure 35—Transect laid up the face and onto crest of roadcut 16, Salina Canyon, Sevier County, UT, where trident saltbrush was seeded.

These species had a higher mean percent cover on the exposed face of the cut than on the crest:

basin wildrye
foxtail barley (*Hordeum jubatum* var. *jubatum*)
alkali sacaton (*Sporobolus airoides* var. *airoides*)
clasping pepperweed
alfalfa
trident saltbush seedlings
green rubber rabbitbrush (*Chrysothamnus nauseosus* ssp. *graveolens*)
black greasewood seedlings
pinyon pine seedlings (*Pinus edulis*)

The mean percent cover for bare ground (59.0 ± 5.4) and rock (17.8 ± 2.8) is about twice as high as on the crest (26.2 ± 11.2 and 9.0 ± 6.0) (table 15). The following species had a higher mean percent cover on the crest: cheatgrass, crested wheatgrass, Nevada bluegrass, bur buttercup, trident saltbush, greasewood, and cryptogams. Litter was also twice as abundant on the crest (table 15).

Trident saltbush was the only species found in all 10 quadrats. Its value for mean percent cover (20.2 ± 17.2) was higher and more variable on the crest than along the face (15.0 ± 0).

Trident saltbush had a higher density on the face of the cut (18.1 ± 3.4) than on the crest (11.0 ± 9.0), probably because growing conditions were less favorable. The face had more plants than the crest, but they were smaller. Four other species had a mean percent cover greater than 1.0 on the face of the cut. They included two perennial grasses, crested wheatgrass (7.9 ± 4.8) and basin wildrye (3.0 ± 1.8); a shrub, greasewood (2.3 ± 1.8); and a perennial forb, alfalfa (1.8 ± 1.8) (table 16). No cryptogams were observed on the face. On the crest they had a mean percent cover of 37.5 ± 0, the highest value for any of the plants (table 15).

Salina Canyon Roadcut Plantings by Direct Seeding

Numerous species and various accessions of these species were planted by direct seeding (dropping seed in shallow furrows) in rows up to 7.6 m (25.0 ft) long. Of 72 different accessions seeded on Salina Canyon roadcuts 10, 17, and 19 (table 1), 21 (29.2 percent) survived (tables 16 and 17; appendix A). These were evaluated in 1986 and 1987. The sites had a southerly exposure ranging from 160 to 240 degrees, slopes that ranged from 18 to 54 percent, and many soil types (see Salina Canyon Area introductory material, p. 23). Average annual precipitation ranged from 253 mm (10.0 in) to 508 mm (20.0 in). Roadcut 19 is 25.8 km (16 miles) west of roadcut 10, with roadcut 2 lying 3.2 km (2 miles) farther west (table 18).

Table 15—Species density and cover class values from a roadcut planting of trident saltbrush in Salina Canyon including mean values and standard error (se)

Species[1]	Origin[2]	Presence in: Number of transects[3]	Presence in: Number of quadrats[4] Face	Presence in: Number of quadrats[4] Crest	Cover class: Face (mean ± se)	Cover class: Crest (mean ± se)	Density: Face (mean ± se)	Density: Crest (mean ± se)
Annual grass								
Bromus tectorum	I	2	2	2	0.12 ± 0.08	7.75 ± 7.75	0.75 ± 0.52	82.00 ±78.0
Perennial grasses								
Agropyron cristatum[5]	I	2	4	2	7.93 ± 4.83	15.00 ± 0	3.24 ± 1.86	4.50 ± 1.50
Elymus cinereus	N	2	4	1	3.00 ± 1.79	0.25 ± 0.25	2.12 ± 1.44	2.00 ± 2.00
Hordeum jubatum var. *jubatum*	N	2	2	0	0.10 ± 0.08	—	0.60 ± 0.40	—
Poa nevadensis	N	1	1	0	—	7.50 ± 7.50	—	3.00 ± 3.00
Sporobolus airoides var. *airoides*	N	1	1	0	0.06 ± 0.06	—	0.50 ± 0.50	—
Annual forbs								
Lepidium perfoliatum	I	2	4	1	0.50 ± 0.30	0.20 ± 0.20	8.10 ± 6.00	12.00 ±12.00
Ranunculus testiculatus	I	2	3	2	0.50 ± 0.30	9.00 ± 6.00	15.60 ± 9.90	97.50 ±22.50
Perennial forb								
Medicago sativa	I	1	1	0	1.80 ± 1.80	—	0.10 ± 0.10	—
Shrubs								
Atriplex gardneri var. *tridentata*	N	2	8	2	15.00 ± 0	20.20 ±17.20	18.10 ± 3.40	11.00 ± 9.00
Atriplex gardneri var. *tridentata* seedlings	N	2	6	0	0.30 ± 0.08	—	6.00 ± 2.60	—
Chrysothamnus nauseous ssp. *graveolens*	N	2	2	0	0.70 ± 0.40	—	0.10 ± 0.10	—
Sarcobatus vermiculatus	N	2	3	2	2.30 ± 1.80	9.00 ± 6.00	2.60 ± 2.60	4.00 ± 0.00
Sarcobatus vermiculatus seedlings	N	1	1	0	0.06 ± 0.06	—	0.30 ± 0.30	—
Tree								
Pinus edulis seedlings	N	1	1	0	0.06 ± 0.06	—	0.10 ± 0.10	—
Cryptogams		1	0	2	—	37.50 ± 0	—	—
Litter		2	8	2	7.50 ± 2.10	15.00 ± 0	—	—
Bare ground		2	8	2	59.00 ± 5.40	26.20 ±11.20	—	—
Rock		2	8	2	17.80 ± 2.80	9.00 ± 6.00	—	—

[1]For common names see appendix A.
[2]I = introduced, N = native, determined from Welsh and others (1988).
[3]Two transects were evaluated.
[4]Ten quadrats were read: five horizontally along the contour of the cut, three up the face, and two on the crest.
[5]Includes *Agropyron desertorum*.

Table 16—Summary of species planted by direct seeding in furrows on three Interstate 70 roadcuts in Salina Canyon, Sevier County, UT

Species[1]	Number of rows species present in			Average number of plants in rows[2]			Average height[3]			Average crown		
	Cut 10	Cut 17	Cut 19	Cut 10	Cut 17	Cut 19	Cut 10 (mean ± se)	Cut 17 (mean ± se)	Cut 19 (mean ± se)	Cut 10 (mean ± se)	Cut 17 (mean ± se)	Cut 19 (mean ± se)
Grasses												
Agropyron cristatum	1		1	26.0		20	30.0 ± 0		59.0 ± 0			37.0 ± 0
A. elmeri			1			13			108.0 ± 0			82.0 ± 0
A. elongatum	2			6.5			82.5 ± 4.5			53.5 ±11.5		
A. intermedium	1	3	2	41.0	3.0	10	43.0 ± 0	77.0 ± 1.5	93.0 ± 1.0	18.0 ± 0	46.7 ± 9.6	64.5 ± 6.5
A. riparium	2			13.5			42.5 ± 3.5			14.5 ± 7.5		
A. trichophorum	1			3.0			60.0 ± 0			23.0 ± 0		
Bromus inermis	1			1.0			61.0 ± 0			35.0 ± 0		
Dactylis glomerata		1			11.0			89.0 ± 0			7.0 ± 0	
Elymus cinereus	1	1	1	4.0	6.0	6?	132.0 ± 0	68.0 ± 0	141.0 ± 0	90.0 ± 0	48.0 ± 0	80.0 ± 0
E. salinus			1			15			61.0 ± 0			63.0 ± 0
Forbs												
Astragalus cibarius		1			3.0			30.0 ± 0			77.0 ± 0	
A. falcatus		1			6.0			49.0 ± 0			78.0 ± 0	
Penstemon palmeri			1			2.0			84.0 ± 0			38.0 ± 0
Penstemon species			1			4.0			46.0 ± 0			40.0 ± 0
Shrubs												
Atriplex canescens		1			2.0			82.0 ± 0			65.0 ± 0	
Ceratoides lanata		1			8.0			40.0 ± 0			16.0 ± 0	
Colutea arborescens		1	1		9.0	4.0		187.0 ± 0	112.0 ± 0		142.0 ± 0	106.0 ± 0
Ephedra viridis		1			20.0			24.0 ± 0			15.0 ± 0	
Kochia prostrata[4]	9		1	16.1		7.0	32.6 ± 1.4		77.0 ± 0	21.6 ± 1.69		78.0 ± 0
Cowania stansburiana		1			3.0			63.0 ± 0			47.0 ± 0	
Purshia tridentata		1			16.0			87.0 ± 0			64.0 ± 0	

Species[1]	Average uniformity			Average vigor			Utilization		
	Cut 10	Cut 17	Cut 19	Cut 10	Cut 17	Cut 19	Cut 10 (mean)	Cut 17 (mean)	Cut 19 (mean)
Grasses									
Agropyron cristatum			8.0 ± 0			8.0 ± 0	0		0
A. elmeri			9.0 ± 0			9.0 ± 0			0
A. elongatum	6.5 ± 0.5			8.5 ± 0.5			0		
A. intermedium	7.0 ± 0	8.0 ± 0	6.0 ± 0	8.0 ± 0	8.7 ± 0.3	8.0 ± 0	0	0	?
A. riparium	6.0 ± 0			7.5 ± 0.5			0		
A. trichophorum	8.0 ± 0			9.0 ± 0			0		
Bromus inermis				8.0 ± 0			0		
Dactylis glomerata		8.0 ± 0			9.0 ± 0			0	
Elymus cinereus	7.0 ± 0	9.0 ± 0	4.0 ± 0	9.0 ± 0	9.0 ± 0	8.0 ± 0	0	0	0
E. salinus			5.0 ± 0			8.0 ± 0			0
Forbs									
Astragalus cibarius		8.0 ± 0			9.0 ± 0			0	
A. falcatus		5.0 ± 0			9.0 ± 0			0	
Penstemon palmeri			7.0 ± 0			8.0 ± 0			3
Penstemon species			7.0 ± 0			9.0 ± 0			0
Shrubs									
Atriplex canescens		7.0 ± 0			8.0 ± 0			0	
Ceratoides lanata		7.0 ± 0			8.0 ± 0			0	
Colutea arborescens		8.0 ± 0	8.0 ± 0		9.0 ± 0	9.0 ± 0		0	0
Ephedra viridis		8.0 ± 0			8.0 ± 0			3	
Kochia prostrata[4]	5.8 ± 0.3		8.0 ± 0	7.4 ± 0.3		9.0 ± 0	0		0
Cowania stansburiana		8.0 ± 0			9.0 ± 0			0	
Purshia tridentata		7.0 ± 0			9.0 ± 0			0	

[1]For common names see appendix A.
[2]Rows were 7.6 m (25 ft) long at cut 10 and 6.1 m (20 ft) long at cuts 17 and 19. Only rows with live plants were included in the data. The grasses were counted by clumps.
[3]Height determined by measuring tallest stem on forbs and shrubs, and by measuring culms on grasses.
[4]Forage kochia (accession U-11-74) had seven clumps showing obvious vegetative reproduction in its row on cut 19. This accession with four others planted in nearby rows spread over an area covering 16 rows. All species in these rows were gone, except the forage kochia. The U-11-74 forage kochia row was the only one of the five that could be evaluated.

Table 17—Species planted by direct seeding in furrows on roadcuts along Interstate 70 in Salina Canyon that did not survive

Species	Common name
Grasses	
Agropyron desertorum	Desert wheatgrass
A. spicatum	Bluebunch wheatgrass
Bromus carinatus	Mountain brome
Dactylis glomerata	Orchard grass
Distichlis species	Saltgrass
Elymus junceus	Russian wildrye
Festuca ovina	Sheep fescue
Hordeum bulbosum	Bulbous barley
Oryzopsis hymenoides	Indian ricegrass
Phleum pratense	Timothy
Poa compressa	Canada bluegrass
Secale montanum	Mountain rye
Sporobolus cryptandrus	Sand dropseed
SPUT[1]	
Stipa comata	Needle-and-thread
Grasslike plant	
Carex species	Sedge species
Forbs	
Achillea millefolium var. *lanulosa*	Western yarrow
Aster chilensis var. *adscendens*	Pacific aster
Aster glaucodes	Blueleaf aster
Artemisia ludoviciana	Louisiana sagewort
	Brewer bittercress
CAEP[1]	
Coronilla varia	Crownvetch
Hydrophyllum capitatum	Ballhead waterleaf
Linum lewisii	Lewis flax
Penstemon acaulis	Stemless penstemon
P. eatonii	Eaton penstemon
P. humilis	Low penstemon
P. platyphyllus	Hillside penstemon
Phlox hoodii canescens	Carpet phlox
Sanguisorba minor	Small burnett
Viguiera multiflora	Showy goldeneye
Shrubs	
Artemisia filifolia	Sand sagebrush
A. nova	Black sagebrush
A. pygmaea	Pygmy sagebrush
A. tridentata ssp. *tridentata*	Basin big sagebrush
Caragana brevispina	
C. microphylla	
Ceratoides lanata	Winterfat
Cercocarpus ledifolius	Curlleaf mountain-mahogany
Chrysothamnus linifolius	Spreading rabbitbrush
C. nauseosus	Rubber rabbitbrush
C. viscidiflorus ssp. *lanceolatus*	Mountain low rabbitbrush
Cornus stolonifera	Redosier dogwood
Persphyllum ramosissimum	Squaw-apple
Prunus virginiana var. *melanocarpa*	Black common chokecherry
Quercus gambelii	Gambel oak
Sambucus cerulea	Blue elderberry
Sarcobatus vermiculatus	Black greasewood
Symphoricarpos longiflorus	Longflower snowberry
S. oreophilus	Mountain snowberry

[1]These codes were used on the original data forms. Species names cannot be determined. If CAEP had been listed under grasses, it would be *Calamagrostis epigeios* (Chee reedgrass).

Table 18—Location and description of study sites for direct seedings and transplants along Highway U.S. 89 in lower Sanpete Valley and Interstate 70 in Salina Canyon, Sevier County, UT

Site	Location and elevation	Description	Direct seeding	Transplants
South of Manti, Sanpete County	Along U.S. 89 1,700 m (5,575 ft)	Roadcut on both sides of road		X
North of Sterling, Sanpete County	Along U.S. 89 1,675 m (5,500 ft)	Roadcut on both sides of road		X
Redmond cut, Sevier County	Along U.S. 89 1,575 m (5,160 ft)	Roadcut on east side of road		X
I-70 on-ramp, Sevier County	Salina/I-70 interchange 1,615 m (5,300 ft)	South-facing roadcut		X
Salina Canyon, cut 2, Sevier County	Along I-70 interchange milepost 72, south side 2,260 m (7,420 ft)	Roadcut		X
Salina Canyon, cut 4, Sevier County	Along I-70, milepost 74 both sides at south lane 2,170 m (7,120 ft)	Roadcut		X
Salina Canyon, cut 5, Sevier County	Along I-70, milepost 77 south side 2,270 m (7,450 ft)	Roadcut		X
Salina Canyon, cut 6, Sevier County	Along I-70, milepost 77 north side 2,230 m (7,320 ft)	Roadcut		X
Salina Canyon, cut 8, Sevier County	Along I-70, milepost 76 north side 2,220 m (7,220 ft)	Roadcut		X
Salina Canyon, cut 9, Sevier County	Along I-70, milepost 74 north side 2,220 m (7,220 ft)	Roadcut		X
Salina Canyon, cut 10, Sevier County	Along I-70, milepost 74 north side 2,200 m (7,220 ft)	Roadcut	X	X
Salina Canyon, cut 11, Sevier County	Along I-70, milepost 74 north side 2,230 m (7,320 ft)	Roadcut		X
Salina Canyon, cut 13, Sevier County	Along I-70, milepost 73 north side 2,220 m (7,280 ft)	Roadcut		X
Salina Canyon, cut 14, Sevier County	Along I-70, milepost 71 north side 2,260 m (7,420 ft)	Roadcut, badly slumped		X (mostly dead or gone)
Salina Canyon, cut 15, Sevier County	Along I-70, milepost 67 north side 1,900 m (6,240 ft)	Roadcut		X (mostly dead)
Salina Canyon, cut 17, Sevier County	Along I-70, milepost 60 north side 1,750 m (5,740 ft)	Roadcut	X	X
Salina Canyon, cut 19, Sevier County	Along I-70, milepost 58 north side 1,730 m (5,670 ft)	Roadcut	X	

The Utah Department of Transportation planted a mixture of grasses and yellow sweetclover on these roadcuts. Shrubs, and some forbs and grasses, were planted afterward. These plantings were generally transplants, although some were direct seedings. Except for cut 19, which had no transplants, these three cuts received all three types of plantings.

All 21 surviving species (table 16) appear to be doing well. Each species had at least a 5.0 average mean uniformity rating (table 16). Forage kochia was the only species planted by direct seeding that showed any significant spread (table 16, footnote 4). Intermediate wheatgrass and basin wildrye survived and performed relatively well at all three sites. No other species survived at all three sites (table 16). Table 17 lists the 50 species that did not survive after planting.

Chickpea milkvetch (*Astragalus cicer*) was broadcast seeded in some seed mixes. Although it was not evaluated, and therefore is not listed in the tables, chickpea milkvetch became established and maintained itself well (fig. 36). It is scattered over the south-facing slope of the Interstate 70 median at roadcut 4 (table 18).

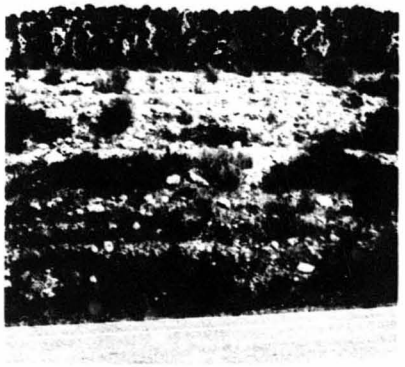


Figure 36—Chickpea milkvetch (large dark clumps) growing on the median of Interstate 70 at roadcut 4, Salina Canyon, Sevier County, UT.

South-Central Utah Transplant Plantings

Numerous accessions of different species and varieties were transplanted at various roadcuts along Highway U.S. 89 in southern Sanpete County and along Interstate 70 in Salina Canyon. Many of the Salina Canyon roadcuts suffered from severe erosion, mudslides, and slumpage during the excessively wet years of 1983 and 1984. This damage took out many of the plantings on the affected cuts. Nevertheless, transplants of 80 surviving species and varieties were evaluated on 13 sites. These sites vary from 1,573 to 2,262 m (5,160 to 7,420 ft) in elevation, from 18 to 49 percent in slope, and from 30 to 355 degrees in aspect. They have many different soil types (tables 1 and 18). The vast majority of the transplanted species were shrubs or small trees. Of the species that survived, 64 (80.0 percent) were shrubs and trees, six (7.5 percent) were forbs, and 10 (12.5 percent) were grasses (appendixes A and D).

Forty-one species had a 25 percent survival rate or better at one or more sites (appendix D). Twenty-eight species had a survival rate of 50 percent or better (table 19). The following species (appendix D) consistently performed well on various sites:

Saskatoon serviceberry (*Amelanchier alnifolia*)
oldman wormwood
black sagebrush
big sagebrush
rubber rabbitbrush
common bladdersenna
Russian olive (*Elaeagnus angustifolia*)
Siberian salttree (*Halimodendron halodendron*)
forage kochia
matrimony vine (*Lycium barbarum*)
squaw-apple (*Peraphyllum ramosissimum*) (fig. 37)
skunkbush sumac
golden currant (*Ribes aureum*)
mountain snowberry

Sixty-one (75.3 percent) of the surviving species appear to be well adapted to their sites, with average vigor ratings of 8 or 9 (appendix D). The following species performed well at two or more sites:

Grasses
- quackgrass
- alkalai sacaton

Shrubs
- oldman wormwood
- big sagebrush
- fourwing saltbush
- Siberian peashrub (*Caragana microphylla*)
- Martin ceanothus (*Ceanothus martinii*)
- rubber rabbitbrush
- whitestemmed rubber rabbitbrush
- common bladdersenna
- Peking cotoneaster
- Nevada ephedra

Table 19—Species transplanted on roadcut along Highway U.S. 89 in lower Sanpete Valley, and Interstate 70 in Salina Canyon, Sevier County, UT, that had a survival rate of 50 percent or better on one or more sites

Species	Common name	Percent survival
Atriplex confertifolia	Shadscale	100.0
Lycium barbarum	Matrimony vine	96.8
Opuntia species	Pricklypear cactus	89.9
Peraphyllum ramosissimum	Squaw-apple	89.7
Artemisia pygmaea	Pygmy sagebrush	88.0
Elaeagnus commutata	Silverberry	85.7
Cotoneaster acutifolia	Peking cotoneaster	81.1
Amelanchier alnifolia	Serviceberry	80.0
Symphoricarpos oreophilus	Mountain snowberry	78.6
Artemisia tridentata	Big sagebrush	77.8
Malus baccata	Siberian crab	77.8
Rhus aromatica var. *trilobota*	Skunkbush	75.0
Caragana arborescens	Siberian peashrub	70.0
Kochia prostrata	Forage kochia	70.0
Prunus tomentosa	Nanking cherry	70.0
Rosa species	Rose	68.2
Artemisia nova	Black sagebrush	66.7
Prunus besseyi	Western sandcherry	64.6
Yucca species	Yucca	64.3
Cowania stansburiana	Cliffrose	61.5
Poa pratensis	Kentucky bluegrass	60.0
Artemisia tridentata ssp. *vaseyana*	Mountain big sagebrush	60.0
Colutea arborescens	Common bladdersenna	60.0
Ribes aureum	Golden currant	59.1
Artemisia arbrotanum	Oldman wormwood	56.5
Rosa woodsii	Woods rose	53.6
Forestiera neomexicana	New Mexican foresteria	52.6
Chrysothamnus nauseosus	Rubber rabbitbrush	50.0

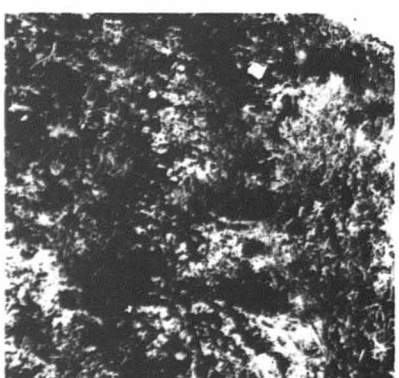


Figure 37—Two rows of squaw-apple transplants on roadcut 5, Salina Canyon, Sevier County, UT.

forage kochia
matrimony vine
squaw-apple
antelope bitterbrush
black common chokecherry
mountain snowberry

Most of these species were also high in average uniformity, another indication they are well adapted to the sites (appendix D).

Common bladdersenna (fig. 38) is the vigor champion on roadcuts in Salina Canyon. It received the highest vigor rating (9) at each of the five sites where it was present. Oldman wormwood, big sagebrush (fig. 39), rubber rabbitbrush, and matrimony vine (fig. 39) also did well at five or more sites (appendix D).

Seventeen species listed in appendix D showed some form of recruitment. Two grasses, quackgrass (fig. 40) and intermediate wheatgrass, spread extensively. A third grass, Salina wildrye (*Elymus salinus*), also spread from its original row of transplants, although not as much. Three forbs, Louisiana

Figure 38—Large, vigorous transplant of common bladdersenna growing on roadcut 2, Salina Canyon, Sevier County, UT.

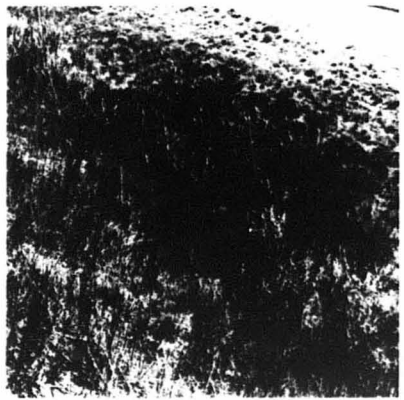


Figure 40—Quackgrass recruitment on roadcut 10, Salina Canyon, Sevier County, UT. It spread from five adjacent rows of transplants to form a patch 4.5 m by 12.5 m.

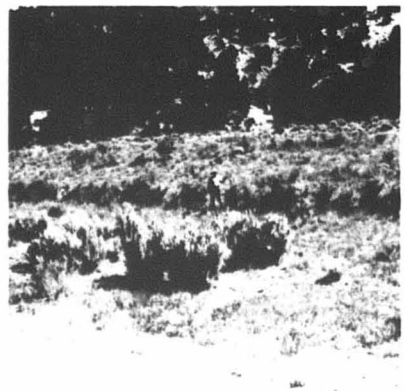


Figure 39—General view of transplants of big sagebrush (foreground) and matrimony vine (alongside researcher in background) on roadcut 8, Salina Canyon, Sevier County, UT. Both species showing excellent vigor (9) for this site.

sagewort (fig. 41), German iris (fig. 42), and salt globepea (*Sphaerophysa salsula*) all showed excellent spread at some sites (appendix D).

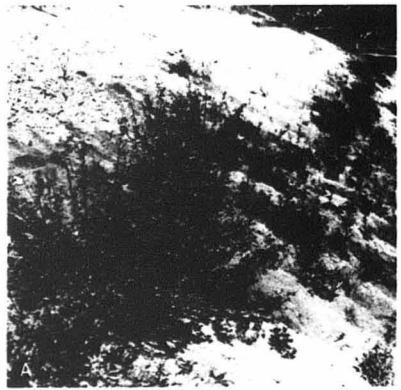
Eleven species of shrubs showed some form of recruitment at one or more of the roadcuts. The most outstanding was matrimony vine, which spread well at all five sites where it was planted (fig. 43). Other shrubs showing excellent recruitment were silver sagebrush (*Artemisia cana*), silverberry (*Elaeagnus commutata*) (fig. 44), Woods rose (fig. 45), and silver buffaloberry (*Shepherdia argentea*) (fig. 46). Six additional shrubs showed some recruitment. They are oldman wormwood (fig. 47), common bladdersenna, forage kochia (fig. 48), Anderson peachbush (*Prunus andersonii*), various species of rose (*Rosa* spp.), and mountain snowberry (fig. 49 and appendix D).

At roadcut 6 near exit 77 (milepost 77) in Salina Canyon, 40 "black" willow (*Salix* spp.) cuttings were planted in an area with seeps in 1975. This area slumped badly in 1983-84. In September 1986, 148 willow shoots were present, exhibiting exceptional recruitment (fig. 50). Curlleaf mountain-mahogany spread down over the upper face of roadcut 5 from a native stand on the crest (fig. 51). Table 20 gives a summary of plants that established well as transplants, and those that established well from seed.

Figure 41—Louisiana sagewort recruitment (low plants in foreground) on roadcut 10, Salina Canyon, Sevier County, UT. It formed two patches, one 1.8 m by 9 m and one 2 m by 2 m, from the original row of transplants.

Figure 42—German iris recruitment on the South Manti roadcut, Sanpete County, UT.

Figure 43—Matrimony vine showing excellent vigor and recruitment at roadcut 8, Salina Canyon, Sevier County, UT. It spread up to 1.5 m from the original transplants. It did even better at other sites (appendix D, footnote 23).



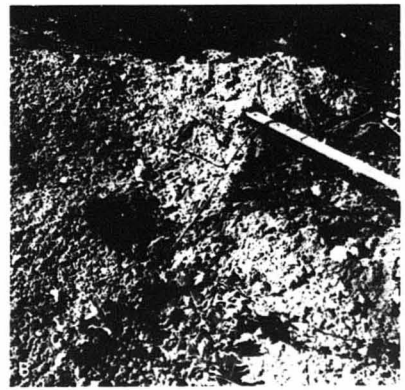


Figure 44—Silverberry showing excellent vigor and recruitment at roadcut 2, Salina Canyon, Sevier County, UT. A. Note the numerous young plants on the lower side of this silverberry row. B. Exposed rhizome of silverberry.

Figure 45—Woods rose showing vegetative spread from original row (note the meter stick [arrow] by original transplants). Spread extended 2 m below and 1 m above the original row at roadcut 13, Salina Canyon, Sevier County, UT.

Figure 46—Silver buffaloberry showing excellent vigor and recruitment at roadcut 2, Salina Canyon, Sevier County, UT. It has spread 1.5 to 2 m from original row. One row with 11 original plants now has 46 new ones.

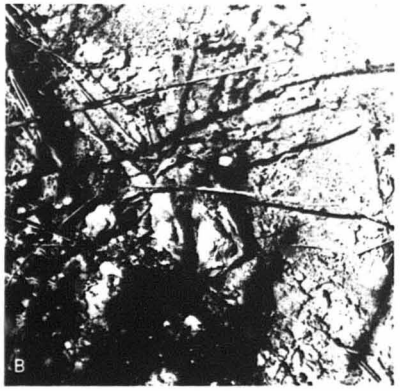


Figure 47—Oldman wormwood showing recruitment by rhizomes, roadcut 2, Salina Canyon, Sevier County, UT. A. Note rhizome with plantlets growing from it. B. Rhizome lifted to show rooting and plantlets. The large rock was placed under the rhizome to hold it up.

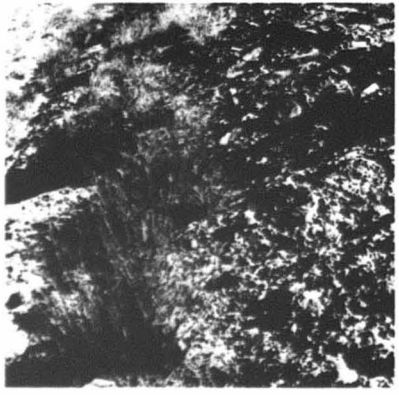


Figure 48—Forage kochia showing excellent vigor and good recruitment on roadcut 5, Salina Canyon, Sevier County, UT. This row of original transplants has spread out to 1.3 m.

Figure 49—Mountain snowberry showing recruitment by layering at roadcut 10, Salina Canyon, Sevier County, UT.

Figure 50—Willow recruitment at roadcut 6, Salina Canyon, Sevier County, UT. The number of shoots increased from the 40 originally planted to 148.

Figure 51—Curlleaf mountain-mahogany recruiting from the native stand on the crest to the face of roadcut 5, Salina Canyon, Sevier County, UT.

Table 20—Plant species that have established well on roadsite plantings in central Utah from direct seedings and transplants

Species[1]	Established by direct seeding	Established by transplanting
Grasses		
Agropyron cristatum	X	
A. elmeri	X	
A. elongatum	X	
A. intermedium	X	X
A. repens	X	X
A. riparium	X	
A. spicatum	X	
A. trachycaulum	X	
A. trichophorum	X	
Bromus inermis	X	
Dactylis glomerata	X	
Elymus cinereus	X	
E. salinus	X	X
Poa pratensis	X	X
Sporobolus airoides		X
Forbs		
Artemisia ludoviciana		X
Astragalus cibarius	X	
A. cicer	X	
A. falcatus	X	
Iris germanica		X
Medicago sativa	X	
Onobrychis viciifolia	X	
Penstemon palmeri	X	
Penstemon species	X	
Salvia sclarea		X
Sphaerophysa salsula		X

(con.)

Table 20 (Con.)

Species[1]	Established by direct seeding	Established by transplanting
Shrubs and trees		
Acer ginnala		X
A. negundo		X
Amelanchier alnifolia		X
Artemisia abrotanum		X
A. cana ssp. *cana*		X
A. nova		X
A. pygmaea		X
A. tridentata		X
A. tridentata ssp. *tridentata*		X
A. tridentata ssp. *vaseyana*		X
Atriplex canescens	X	X
A. confertifolia	X	
A. gardneri var. *tridentata*	X	
Caragana aborescens		X
C. microphylla		X
Ceanothus martinii		X
Celtus occidentalis		X
Ceratoides lanata	X	
Chrysothamnus nauseosus		X
C. nauseosus ssp. *hololeucus*		X
Colutea arborescens		X
Cornus sericea var. *sericea*		X
Cotoneaster acutifolia		X
Cowania stansburiana	X	X
Cupressus arizonica	X	X
Eleagnus angustifolia		X
E. commutata		X
Ephedra nevadensis		X
E. viridis	X	
Foestiera neomexicana		X
Fraxinus pennsylvanica		X
Halimodendron halodendron		X
Kochia prostrata	X	X
Lonicera tatarica		X
Lycium barbarum		X
Malus baccata		X
Morus alba var. *tatarica*		X
Opuntia species		X
Peraphyllum ramosissimum		X
Prunus americana		X
P. besseyi		X
P. siberica		X
P. spinosa		X
P. tomentosa		X
P. virginiana var. *melanocarpa*		X
Purshia tridentata	X	X
Rhus aromatica var. *trilobata*		X
Ribes aureum		X
Rosa hansenii		X
Rosa species		X
R. woodsii		X
Salix purpurea var. *lambertiana*		X
Salix species		X
Shepherdia argentea		X
Symphoricarpos oreophilus		X
Syringa villosa		X
S. vulgaris		X
Yucca species		X

[1]For common names see appendix A.

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APPENDIX A: PLANT MATERIALS[1] EVALUATED ON ROADSIDE PLANTINGS IN SOUTH-CENTRAL UTAH

All Materials—Nephi, Fairview, and Ephraim Canyons; Juab and Sanpete Counties

Note: Footnotes for entire appendix are on page 60; see additional site headings on pages 53 and 57.

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] N	F1	F2	F3	F4	F5	F6	ES	EP	EK	EG	EB	EW
Grasses																
Aegilops cylindrica	Jointed goatgrass	A	I								X	X	X			
Agropyron cristatum[6]	Fairway crested wheatgrass	P	I								X	X	X			
A. elmeri	Elmer wheatgrass	P	N													
A. elongatum	Tall wheatgrass	P	I													
A. intermedium	Intermediate wheatgrass	P	I											X		
A. repens	Quackgrass	P	I											X		
A. riparium	Streambank wheatgrass	P	N													
A. smithii	Western wheatgrass	P	N													
A. spicatum var. *inerme*	Beardless bluebunch wheatgrass	P	N											X		
A. trachycaulum	Slender wheatgrass	P	N											X		
A. trichophorum	Pubescent wheatgrass	P	I											X		
Bromus inermis	Smooth brome	P	I											X		
B. japonicus	Japanese chess	A	I	X							X	X				
B. tectorum	Cheatgrass	A	I	X							X	X	X			
Calamagrostis epigeios[7]	Chee reedgrass	P	I													
Dactylis glomerata	Orchard grass	P	I									X		X		
Festuca ovina var. *duriuscula*	Hard sheep fescue	P	N										X			
Elymus cinereus	Great Basin wildrye	P	N													
E. giganteus	Mammoth wildrye	P	I													
E. salinus	Salina wildrye	P	N													
Hilaria jamesii	Galleta grass	P	N													
Hordeum jubatum	Foxtail barley	P	N													
Oryzopsis hymenoides	Indian ricegrass	P	N	X								X	X			
Phleum pratense	Timothy	P	I											X		
Poa bulbosa	Bulbous bluegrass	P	I									X	X			
P. pratensis	Kentucky bluegrass	P	N											X		
P. nevadensis	Nevada bluegrass	P	N													
P. secunda	Sandberg bluegrass	P	N													
Secale cereale	Winter rye	A(B)	I								X					
Sitanion hystrix	Bottlebrush squirreltail	P	N	X							X	X	X			
Sporobolus airoides	Alkali sacaton	P	N													
S. contractus	Spike dropseed	P	N													
Stipa comata	Needle-and-thread	P	N													
Forbs																
Achillea millefolium ssp. *lanulosa*	Western yarrow	P	N													
Alyssum alyssoides	Pale alyssum	A	N	X												
Arenaria fendleri	Fendler sandwort	P	N	X												
Arenaria species	Sandwort species	?	N													
Artemisia ludoviciana	Louisiana sagewort	P	N						X							
Aster chilensis var. *adscendens*	Pacific aster	P	N	X					X		X					
Astragalus cibarius	Silky milkvetch	P	N													
A. cicer	Chickpea milkvetch	P	I											X		

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] N	F1	F2	F3	F4	F5	F6	ES	EP	EK	EG	EB	EW
A. convallarius	Timber poisonvetch	P	N								X			X		
A. falcatus	Sicklepod milkvetch	P	I													
A. kentrophyta	Kentrophyta milkvetch	P	N													
Astragalus species	Milkvetch species	P	N											X		
Balsamorhiza sagittata	Arrowleaf balsamroot	P	N											X		
Calochortus nuttallii	Sego lily	P	N													
Chrysanthemum balsamita	Costmary	P	I													
Convolvulus arvensis	Field bindweed	P	I	X								X	X	X		
Cryptantha species	Cryptantha species	?	N													
Cynoglossum officinale	Common houndstongue	B	I	X										X		
Descurainia sophia	Tansy mustard	A	I													
Erigeron species	Fleabane daisy species	P	N											X		
Eriogonum brevicaule var. *laxifolium*	Shortstem wild buckwheat	N														
E. hookeri	Watson buckwheat	A	N													
E. umbellatum	Sulfur buckwheat	P	N													
Erodium cicutarium	Storksbill (Alfileria)	A	I								X		X			
Gilia species	Gilia species	?	N													
Gilia congesta	Ballhead gilia	B(P)	N													
Grindelia squarrosa	Curlycup gumweed	B(P)	N									X	X			
Halogeton glomeratus	Halogeton	A	I													
Hedysarum boreale var. *germinale*	Utah sweetvetch	P	N													
Iris germanica	German iris	P	I		X	X	X		X					X		
Iva axillaris	Poverty sumpweed	P	N	X												
Kochia scoparia	Summer-cypress	A	I													
Lactuca serriola	Prickly lettuce	B	N													
Langloisia schottii		A	N													
Lappula occidentalis var. *cupulata*	Western stickseed	A	N													
Lathyrus lanszwertii	Thickleaf peavine	P	N											X		
Lepidium perfoliatum	Clasping pepperweed	A	I													
Malcolmia africana	African mustard	A	I													
Medicago sativa	Alfalfa	P	I											X		
Melilotus alba	White sweetclover	A(B)	I	X												
M. officinalis	Yellow sweetclover	A(B)	I													
Microsteris gracilis	Little polecat	A	N													
Oenothera species	Evening-primrose	?	N													
Onobrychis transcaucasica	Sainfoin	P	I													
O. viciifolia	Common sainfoin	P	I								X		X			
Penstemon palmeri	Palmer penstemon	P	N									X				
Penstemon species	Penstemon species	P	N													
Phlox hoodii	Carpet phlox	P	N													
P. longifolia	Longleaf phlox	P	N													
Physaria species	Twinpod species	P	N													
Ranunculus testiculatus	Bur buttercup	A	I									X	X			
Rubia tinctoria	Madder	P	I	X												
Salsola iberica	Russian thistle	A	I													
Salvia sclarea	Clary sage	B	I	X												
Sanguisorba minor	Small burnet	P	N													
Sphaeralcea coccinea	Scarlet globemallow	P	N	X								X				
S. grossulariaefolia	Gooseberryleaf globemallow	P	N													
Sphaerophysa salsula	Salt globepea	P	I													
Stellaria jamesiana	Tuber starwort	N	P											X		
Tragopogon dubius	Yellow salsify	B	I								X	X				

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] N	F1	F2	F3	F4	F5	F6	ES	EP	EK	EG	EB	EW
Shrubs and trees																
Acer ginnala	Amur maple	P	I						X							
A. negundo	Boxelder	P	N			X			X							
Acer species	Maple species	P	?													
Amelanchier alnifolia	Saskatoon serviceberry	P	N						X							
Artemisia abrotanum	Oldman wormwood	P	I		X	X	X	X	X	X				X		X
A. cana ssp. *cana*	Silver sagebrush	P	N													
A. nova	Black sagebrush	P	N	X												
A. pygmaea	Pygmy sagebrush	P	N													
A. tridentata	Big sagebrush	P	N		X											
A. tridentata ssp. *tridentata*	Basin big sagebrush	P	N	X												
A. tridentata ssp. *vaseyana*	Mountain big sagebrush	P	N													
A. tridentata ssp. *wyomingensis*	Wyoming big sagebrush	P	N									X				
Atriplex canescens	Fourwing saltbush	P	N													
A. confertifolia	Shadscale	P	N													
A. gardneri ssp. *tridentata*	Trident saltbush	P	N													
Caragana arborescens	Siberian peashrub	P	I		X				X							
C. arborescens var. *pygmaea*	Pygmy peashrub	P	I													
C. brevispina		P	I													
C. microphylla		P	I													
Ceanothus martinii	Martin ceanothus	P	N													
C. velutinus	Snowbrush ceanothus	P	N													
Celtis occidentalis	Common hackberry	P	I						X							
Ceratoides lanata	Winterfat	P	N													
Cercocarpus ledifolius	Curlleaf mountain-mahogany	P	N													
C. montanus	True mountain-mahogany	P	N	X												
Chrysothamnus nauseosus	Rubber rabbitbrush	P	N													
C. nauseosus ssp. *consimilis*	Threadleaf rubber rabbitbrush	P	N													
C. nauseosus ssp. *graveolens*	Green rubber rabbitbrush	P	N													
C. nauseosus ssp. *hololeucus*	White rubber rabbitbrush	P	N		X				X			X				
C. nauseosus ssp. *salicifolius*	Mountain rubber rabbitbrush	P	N													
C. vicidiflorus ssp. *puberulus*	Hairy low rabbitbrush	P	N										X			
Colutea arborescens	Common bladdersenna	P	I	X	X											
Cornus sericea	Redosier dogwood	P	N						X							
Cotoneaster acutifolia	Peking cotoneaster	P	I			X			X							
Cowania stansburiana	Stansbury cliffrose	P	N		X											
Cupressus arizonica	Arizona cypress	P	I					X								
Elaeagnus angustifolia	Russian olive	P	I	X												
E. commutata	Silverberry	P	N													
E. umbellatum	Autumn elaeagnus	P	I													
Ephedra nevadensis	Nevada ephedra	P	N													
E. viridis	Green ephedra	P	N													
Eriogonum heracleoides	Whorled buckwheat	P	N													
Forestiera neomexicana	New Mexican forestiera	P	I					X								
Fraxinus pennsylvanica	Green ash	P	I						X							

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] N	F1	F2	F3	F4	F5	F6	ES	EP	EK	EG	EB	EW
Gutierrezia sarothrae	Broom snakeweed	P	N										X			
Halimodendron halodendron	Siberian salttree	P	I													
Kochia americana	Gray molly	P	N													
Kochia prostrata	Forage kochia	P	I										X			
Lonicera tatarica	Tatarian honeysuckle	P	I	X	X	X										
Lycium barbarum	Matrimony vine	P	I						X							
Malus baccata	Siberian crab	P	I													
Morus alba var. *tatarica*	Russian mulberry	P	I						X							
Opuntia species	Pricklypear species	P	N													
Peraphyllum ramosissimum	Squaw-apple	P	N													
Pinus edulis	Pinyon pine	P	N			X										
Populus fremontii	Fremont cottonwood	P	N													
Prunus americana	American plum; pottawattami	P	N			X			X	X						
P. andersonii	Anderson peachbrush	P	I													
P. besseyi	Western sandcherry	P	I			X			X							
P. fasciculata	Desert peachbrush	P	N													
P. siberica	Sloe cherry	P	I						X							
P. spinosa	Blackthorn	P	I						X							
P. tomentosa	Nanking cherry	P	I													
P. virginiana var. *melanocarpa*	Black common chokecherry	P	N		X											
Potentilla fruticosa	Bush cinquefoil	P	N						X							
Purshia tridentata	Antelope bitterbrush	P	N	X												
Quercus gambelii	Gambel oak	P	N	X	X									X		
Rhus glabra	Rocky Mountain smooth sumac	P	N	X												
R. aromatica var. *trilobata*	Skunkbush sumac	P	N	X												
Ribes aureum	Golden currant	P	N		X											
Robinia pseudoacacia	Black locust	P	I			X										
Rosa hansenii	Hansen rose	P	I			X			X							
Rosa species	Rose species	P	?						X							
R. woodsii	Woods rose	P	N	X										X		
Salix purpurea	Purpleosier willow	P	I						X							
Salix species[9]	"Black" willow	P	?													
Sambucus cerulea	Blueberry elder	P	N					X								
Sarcobatus vermiculatus	Black greasewood	P	N													
Shepherdia argentea	Silver buffaloberry	P	N													
Sorbus scopulina	American mountain ash	P	N													
Symphoricarpos oreophilus	Mountain snowberry	P	N	X	X				X						X	
Syringa villosa	Late lilac	P	I						X							
S. vulgaris	Common lilac	P	I	X	X	X			X							
Syringa species	Lilac	P	I													
Tetradymia canescens	Gray horsebrush	P	N										X			
T. spinosa	Spiny horsebrush	P	N													
Ulmus parvifolia	Chinese elm	P	I													
Yucca species	Yucca species	P	N													

Direct Seedings—Sanpete and Sevier Valleys and Salina Canyon; Sanpete and Sevier Counties

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] K	FS	FO	FF	W1	W18	W20	B	D10	D17	D19
Grasses														
Aegilops cylindrica	Jointed goatgrass	A	I	X										
Agropyron cristatum[6]	Fairway crested wheatgrass	P	I	X		X	X	X	X		X	X		X
A. elmeri	Elmer wheatgrass	P	N											X
A. elongatum	Tall wheatgrass	P	I	X								X		
A. intermedium	Intermediate wheatgrass	P	I	X				X	X			X	X	X
A. repens	Quackgrass	P	I	X										
A. riparium	Streambank wheatgrass	P	N									X		
A. smithii	Western wheatgrass	P	N	X										
A. spicatum var. *inerme*	Beardless bluebunch wheatgrass	P	N	X										
A. trachycaulum	Slender wheatgrass	P	N											
A. trichophorum	Pubescent wheatgrass	P	I	X								X		
Bromus inermis	Smooth brome	P	I	X								X		
B. japonicus	Japanese chess	A	I											
B. tectorum	Cheatgrass	A	I	X	X	X	X		X		X			
Calamagrostis epigeios[7]	Chee reedgrass	P	I											
Dactylis glomerata	Orchard grass	P	I									X		
Festuca ovina var. *duriuscula*	Hard sheep fescue	P	N	X										
Elymus cinereus	Great Basin wildrye	P	N	X							X	X	X	X
E. giganteus	Mammoth wildrye	P	I											
E. salinus	Salina wildrye	P	N											X
Hilaria jamesii	Galleta grass	P	N	X										
Hordeum jubatum var. *jubatum*	Foxtail barley	P	N								X			
Oryzopsis hymenoides	Indian ricegrass	P	N	X		X			X					
Phleum pratense	Timothy	P	I											
Poa bulbosa	Bulbous bluegrass	P	I	X										
P. pratensis	Kentucky bluegrass	P	N											
P. nevadensis	Nevada bluegrass	P	N	X							X			
P. secunda	Sandberg bluegrass	P	N	X										
Secale cereale	Winter rye	A(B)	I	X										
Sitanion hystrix	Bottlebrush squirreltail	P	N	X										
Sporobolus airoides	Alkali sacaton	P	N								X			
S. contractus	Spike dropseeed	P	N	X										
Stipa comata	Needle-and-thread	P	N	X		X			X					
Forbs														
Achillea millefolium ssp. *lanulosa*	Western yarrow	P	N											
Alyssum alyssoides	Pale alyssum	A	N		X									
Arenaria fendleri	Fendler sandwort	P	N	X										
Arenaria species	Sandwort species	?	N	X										
Artemisia ludoviciana	Louisiana sagewort	P	N											
Aster chilensis var. *adscendens*	Pacific aster	P	N											
Astragalus cibarius	Silky milkvetch	P	N										X	
A. cicer	Chickpea milkvetch	P	I											
A. convallarius	Timber poisonvetch	P	N											
A. falcatus	Sicklepod milkvetch	P	I										X	
A. kentrophyta	Kentrophyta milkvetch	P	N	X					X					
Astragalus species	Milkvetch species	P	N	X										
Balsamorhiza sagittata	Arrowleaf balsamroot	P	N											
Calochortus nuttallii	Sego lily	P	N	X										

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5]										
				K	FS	FO	FF	W1	W18	W20	B	D10	D17	D19
Chrysanthemum balsamita	Costmary	P	I											
Convolvulus arvensis	Field bindweed	P	I	X										
Cryptantha species	Cryptantha species	?	N	X										
Cynoglossum officinale	Common houndstongue	B	I											
Descurainia sophia	Tansy mustard	A	I	X	X		X							
Erigeron species	Fleabane daisy species	P	N											
Eriogonum brevicaule var. *laxifolium*	Shortstem wild buckwheat	P	N	X										
E. hookeri	Watson buckwheat	A	N	X										
E. umbellatum	Sulfur buckwheat	P	N	X				X	X					
Erodium cicutarium	Storksbill (Alfileria)	A	I	X										
Gilia species	Gilia species	?	N	X										
Gilia congesta	Ballhead gilia	B(P)	N	X										
Grindelia squarrosa	Curlycup gumweed	B(P)	N	X					X					
Halogeton glomeratus	Halogeton	A	I	X			X							
Hedysarum boreale var. *germinale*	Utah sweetvetch	P	N	X										
Iris germanica	German iris	P	I											
Iva axillaris	Poverty sumpweed	P	N	X										
Kochia scoparia	Summer-cypress	A	I	X	X									
Lactuca serriola	Prickly lettuce	B	N	X			X			X				
Langloisia schottii		A	N	X										
Lappula occidentalis var. *cupulata*	Western stickreed	A	N	X			X							
Lathyrus lanszwertii	Thickleaf peavine	P	N											
Lepidium perfoliatum	Clasping pepperweed	A	I	X							X			
Malcolmia africana	African mustard	A	I	X	X	X	X			X				
Medicago sativa	Alfalfa	P	I								X			
Melilotus alba	White sweetclover	A(B)	I											
M. officinalis	Yellow sweetclover	A(B)	I	X										
Microsteris gracilis	Little polecat	A	N	X										
Oenothera species	Evening-primrose	?	N	X										
Onobrychis transcaucasica	Sainfoin	P	I											
O. viciifolia	Common sainfoin	P	I	X										
Penstemon palmeri	Palmer penstemon	P	N											X
Penstemon species	Penstemon species	P	N											X
Phlox hoodii	Carpet phlox	P	N	X										
P. longifolia	Longleaf phlox	P	N	X										
Physaria species	Twinpod species	P	N	X										
Ranunculus testiculatus	Bur buttercup	A	I	X		X					X			
Rubia tinctoria	Madder	P	I											
Salsola iberica	Russian thistle	A	I	X			X			X				
Salvia sclarea	Clary sage	B	I											
Sanguisorba minor	Small burnet	P	I	X										
Sphaeralcea coccinea	Scarlet globemallow	P	N	X										
S. grossulariaefolia	Gooseberryleaf globemallow	P	N	X										
Sphaerophysa salsula	Salt globepea	P	I											
Stellaria jamesiana	Tuber starwort	N	N											
Tragopogon dubius	Yellow salsify	B	I	X										
Shrubs and trees														
Acer ginnala	Amur maple	P	I											
A. negundo	Boxelder	P	N											
Acer species	Maple species	P	?											
Amelanchier alnifolia	Saskatoon serviceberry	P	N											
Artemisia abrotanum	Oldman wormwood	P	I											

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5]										
				K	FS	FO	FF	W1	W18	W20	B	D10	D17	D19
A. cana ssp. *cana*	Silver sagebrush	P	N											
A. nova	Black sagebrush	P	N	X										
A. pygmaea	Pygmy sagebrush	P	N	X										
A. tridentata	Big sagebrush	P	N											
A. tridentata ssp. *tridentata*	Basin big sagebrush	P	N		X	X								
A. tridentata ssp. *vaseyana*	Mountain big sagebrush	P	N											
A. tridentata ssp. *wyomingensis*	Wyoming big sagebrush	P	N	X										
Atriplex canescens	Four-wing saltbush	P	N	X	X	X	X						X	
A. confertifolia	Shadscale	P	N	X		X	X		X	X				
A. gardneri ssp. *tridentata*	Trident saltbush	P	N								X			
Caragana arborescens	Siberian peashrub	P	I											
C. arborescens var. *pygmaea*	Pygmy peashrub	P	I											
C. brevispina		P	I											
C. microphylla		P	I											
Ceanothus martinii	Martin ceanothus	P	N											
C. velutinus	Snowbrush ceanothus	P	N											
Celtus occidentalis	Common hackberry	P	I						X					
Ceratoides lanata	Winterfat	P	N	X				X	X	X			X	
Cercocarpus ledifolius	Curlleaf mountain-mahogany	P	N											
C. montanus	True mountain-mahogany	P	N											
Chrysothamnus *nauseosus*	Rubber rabbitbrush	P	N											
C. nauseosus ssp. *consimilis*	Threadleaf rubber rabbitbrush	P	N	X										
C. nauseosus ssp. *graveolens*	Green rubber rabbitbrush	P	N	X							X			
C. nauseosus ssp. *hololeucus*	White rubber rabbitbrush	P	N	X										
C. nauseosus ssp. *salicifolius*	Mountain rubber rabbitbrush	P	N											
C. vicidiflorus ssp. *puberulus*	Hairy low rabbitbrush	P	N	X										
Colutea arborescens	Common bladdersenna	P	I										X	X
Cornus sericea	Redosier dogwood	P	N											
Cotoneaster acutifolia	Peking cotoneaster	P	I											
Cowania stansburiana	Stansbury cliffrose	P	N										X	
Cupressus arizonica	Arizona cypress	P	I											
Elaeagnus angustifolia	Russian olive	P	I											
E. commutata	Silverberry	P	N											
E. umbellatum	Autumn elaeagnus	P	I											
Ephedra nevadensis	Nevada ephedra	P	N	X										
E. viridis	Green ephedra	P	N	X									X	
Eriogonum heracleoides	Whorled buckwheat	P	N											
Forestiera neomexicana	New Mexican forestiera	P	I											
Fraxinus pennsylvanica	Green ash	P	I											
Gutierrezia sarothrae	Broom snakeweed	P	N	X										
Halimodendron halodendron	Siberian salttree	P	I											
Kochia americana	Gray molly	P	N	X					X					
Kochia prostrata	Forage kochia	P	I	X				X		X		X		X
Lonicera tatarica	Tatarian honeysuckle	P	I											
Lycium barbarum	Matrimony vine	P	I											

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5]										
				K	FS	FO	FF	W1	W18	W20	B	D10	D17	D19
Malus baccata	Siberian crab	P	I											
Morus alba var. *tatarica*	Russian mulberry	P	I											
Opuntia species	Pricklypear species	P	N	X										
Peraphyllum ramosissimum	Squaw-apple	P	N											
Pinus edulis	Pinyon pine	P	N								X			
Populus fremontii	Fremont cottonwood	P	N											
Prunus americana	American plum; pottawattami	P	N											
P. andersonii	Anderson peachbrush	P	I											
P. besseyi	Western sandcherry	P	I											
P. fasciculata	Desert peachbrush	P	N											
P. siberica	Sloe cherry	P	I											
P. spinosa	Blackthorn	P	I											
P. tomentosa	Nanking cherry	P	I											
P. virginiana var. *melanocarpa*	Black common chokecherry	P	N											
Potentilla fruticosa	Bush cinquefoil	P	N											
Purshia tridentata	Antelope bitterbrush	P	N										X	
Quercus gambelii	Gambel oak	P	N											
Rhus glabra	Rocky Mountain smooth sumac	P	N											
R. aromatica var. *trilobata*	Skunkbush sumac	P	N											
Ribes aureum	Golden currant	P	N											
Robinia pseudoacacia	Black locust	P	I											
Rosa hansenii	Hansen rose	P	I											
Rosa species	Rose species	P	?											
R. woodsii	Woods rose	P	N											
Salix purpurea	Purpleosier willow	P	I											
Salix species[8]	"Black" willow	P	?											
Sambucus cerulea	Blueberry elder	P	N											
Sarcobatus vermiculatus	Black greasewood	P	N	X	X	X					X			
Shepherdia argentea	Silver buffaloberry	P	N											
Sorbus scopulina	American mountain-ash	P	N											
Symphoricarpos oreophilus	Mountain snowberry	P	N											
Syringa villosa	Late lilac	P	I											
S. vulgaris	Common lilac	P	I											
Syringa species	Lilac	P	I											
Tetradymia canescens	Gray horsebrush	P	N	X										
T. spinosa	Spiny horsebrush	P	N	X										
Ulmus parvifolia	Chinese elm	P	I											
Yucca species	Yucca species	P	N											

Transplants—Sanpete and Sevier Valleys and Salina Canyon; Sanpete and Sevier Counties

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5]												
				TM	TS	TR	TO	T2	T4	T5	T8	T9	T10	T11	T13	T17
Grasses																
Aegilops cylindrica	Jointed goatgrass	A	I													
Agropyron cristatum[6]	Fairway crested wheatgrass	P	I										X			
A. elmeri	Elmer wheatgrass	P	N													
A. elongatum	Tall wheatgrass	P	I													
A. intermedium	Intermediate wheatgrass	P	I										X			
A. repens	Quackgrass	P	I										X		X	X
A. riparium	Streambank wheatgrass	P	N													
A. smithii	Western wheatgrass	P	N													
A. spicatum var. *inerme*	Beardless bluebunch wheatgrass	P	N													
A. trachycaulum	Slender wheatgrass	P	N													
A. trichophorum	Pubescent wheatgrass	P	I													
Bromus inermis	Smooth brome	P	I										X			
B. japonicus	Japanese chess	A	I													
B. tectorum	Cheatgrass	A	I													
Calamagrostis epigeios[7]	Chee reedgrass	P	I													
Dactylis glomerata	Orchard grass	P	I										X			
Festuca ovina var. *duriuscula*	Hard sheep fescue	P	N													
Elymus cinereus	Great Basin wildrye	P	N										X			
E. giganteus	Mammoth wildrye	P	I										X			
E. salinus	Salina wildrye	P	N													X
Hilaria jamesii	Galleta grass	P	N													
Hordeum jubatum	Foxtail barley	P	N													
Oryzopsis hymenoides	Indian ricegrass	P	N													
Phleum pratense	Timothy	P	I													
Poa bulbosa	Bulbous bluegrass	P	I													
P. pratensis	Kentucky bluegrass	P	N													X
P. nevadensis	Nevada bluegrass	P	N													
Poa secunda	Sandberg bluegrass	P	N													
Secale cereale	Winter rye	A(B)	I													
Sitanion hystrix	Bottlebrush squirreltail	P	N													
Sporobolus airoides	Alkali sacaton	P	N								X					X
S. contractus	Spike dropseed	P	N													
Stipa comata	Needle-and-thread	P	N													
Forbs																
Achillea millefolium ssp. *lanulosa*	Western yarrow	P	N										X			
Alyssum alyssoides	Pale alyssum	A	N													
Arenaria fendleri	Fendler sandwort	P	N													
Arenaria species	Sandwort species	?	N													
Artemisia ludoviciana	Louisiana sagewort	P	N										X			
Aster chilensis var. *adscendens*	Pacific aster	P	N													
Astragalus cibarius	Silky milkvetch	P	N													
A. cicer	Chickpea milkvetch	P	I													
A. convallarius	Timber poisonvetch	P	N													
A. falcatus	Sicklepod milkvetch	P	I													
A. kentrophyta	Kentrophyta milkvetch	P	N													
Astragalus species	Milkvetch species	P	N													
Balsamorhiza sagittata	Arrowleaf balsamroot	P	N													
Calochortus nuttallii	Sego lily	P	N													

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] TM	TS	TR	TO	T2	T4	T5	T8	T9	T10	T11	T13	T17
Chrysanthemum balsamita	Costmary	P	I										X			
Convolvulus arvensis	Field bindweed	P	I													
Cryptantha species	Cryptantha species	?	N													
Cynoglossum officinale	Common houndstongue	B	I													
Descurainia sophia	Tansy mustard	A	I													
Erigeron species	Fleabane daisy species	P	N													
Eriogonum brevicaule var. *laxifolium*	Shortstem wild buckwheat	P	N													
E. hookeri	Watson buckwheat	A	N													
E. umbellatum	Sulfur buckwheat	P	N													
Erodium cicutarium	Storksbill (Alfileria)	A	I													
Gilia species	Gilia species	?	N													
Gilia congesta	Ballhead gilia	B(P)	N													
Grindelia squarrosa	Curlycup gumweed	B(P)	N													
Halogeton glomeratus	Halogeton	A	I													
Hedysarum boreale var. *germinale*	Utah sweetvetch	P	N													
Iris germanica	German iris	P	I	X	X	X	X	X	X				X			
Iva axillaris	Poverty sumpweed	P	N													
Kochia scoparia	Summer-cypress	A	I													
Lactuca serriola	Prickly lettuce	B	I													
Langloisia schottii		A	N													
Lappula occidentalis var. *cupulata*	Western stickreed	A	N													
Lathyrus lanszwertii	Thickleaf peavine	P	N													
Lepidium perfoliatum	Clasping pepperweed	A	I													
Malcolmia africana	African mustard	A	I													
Medicago sativa	Alfalfa	P	I													
Melilotus alba	White sweetclover	A(B)	I													
M. officinalis	Yellow sweetclover	A(B)	I													
Microsteris gracilis	Little polecat	A	N													
Oenothera species	Evening-primrose	?	N													
Onobrychis transcaucasica	Sainfoin	P	I							X						
Onobrychis vicilfolia	Common sainfoin	P	I							X						
Penstemon palmeri	Palmer penstemon	P	N													
Penstemon species	Penstemon species	P	N													
Phlox hoodii	Carpet phlox	P	N													
P. longifolia	Longleaf phlox	P	N													
Physaria species	Twinpod species	P	N													
Ranunculus testiculatus	Bur buttercup	A	I													
Rubia tinctoria	Madder	P	I													
Salsola iberica	Russian thistle	A	I													
Salvia sclarea	Clary sage	B	I													
Sanguisorba minor	Small burnet	P	I													
Sphaeralcea coccinea	Scarlet globemallow	P	N													
S. grossulariaefolia	Gooseberryleaf globemallow	P	N													
Sphaerophysa salsula	Salt globepea	P	I												X	
Stellaria jamesiana	Tuber starwort	P	N													
Tragopogon dubius	Yellow salsify	B	I													
Shrubs and Trees																
Acer ginnala	Amur maple	P	I					X								
A. negundo	Boxelder	P	N													
Acer species	Maple species	P	?					X								
Amelanchier alnifolia	Saskatoon serviceberry	P	N					X						X	X	
Artemisia abrotanum	Oldman wormwood	P	I					X	X		X		X	X	X	

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5] TM	TS	TR	TO	T2	T4	T5	T8	T9	T10	T11	T13	T17
A. cana ssp. *cana*	Silver sagebrush	P	N					X								
A. nova	Black sagebrush	P	N	X	X											
A. pygmaea	Pygmy sagebrush	P	N								X					
A. tridentata	Big sagebrush	P	N		X			X			X	X	X			X
A. tridentata ssp. *tridentata*	Basin big sagebrush	P	N										X			
A. tridentata ssp. *vaseyana*	Mountain big sagebrush	P	N											X		
A. tridentata ssp. *wyomingensis*	Wyoming big sagebrush	P	N													
Atriplex canescens	Fourwing saltbush	P	N			X				X	X		X			
A. confertifolia	Shadscale	P	N													X
A. gardneri ssp. *tridentata*	Trident saltbush	P	.•								X					
Caragana arborescens	Siberian peashrub	P	I					X	X				X		X	
C. arborescens var. *pygmaea*	Fygmy peashrub	P	I										X			
C. brevispina		P	I					X								
C. microphylla		P	I								X		X			X
Ceanothus martinii	Martin ceanothus	P	N					X					X			
C. velutinus	Snowbrush ceanothus	P	N					X								
Celtis occidentalis	Common hackberry	P	I													
Ceratoides lanata	Winterfat	P	N							X						
Cercocarpus ledifolius	Curlleaf mountain-mahogany	P	N													X
C. montanus	True mountain-mahogany	P	N							X						
Chrysothamnus nauseosus	Rubber rabbitbrush	P	N					X		X	X	X	X			
C. nauseosus ssp. *consimilis*	Threadleaf rubber rabbitbrush	P	N								X					
C. nauseosus ssp. *graveolens*	Green rubber rabbitbrush	P	N													
C. nauseosus ssp. *hololeucus*	White rubber rabbitbrush	P	N								X		X			
C. nauseosus ssp. *salicifolius*	Mountain rubber rabbitbrush	P	N					X								
C. vicidiflorus ssp. *puberulus*	Hairy low rabbitbrush	P	N													
Colutea arborescens	Common bladdersenna	P						X	X		X		X		X	
Cornus sericea	Redosier dogwood	P	N													
Cotoneaster acutifolia	Peking cotoneaster	P	I					X							X	
Cowania stansburiana	Stansbury cliffrose	P	N					X								
Cupressus arizonica	Arizona cypress	P	I													
Elaeagnus angustifolia	Russian olive	P	I					X	X							X
E. commutata	Silverberry	P	N					X								
E. umbellatum	Autumn elaeagnus	P	I					X								
Ephedra nevadensis	Nevada ephedra	P	N								X		X			X
E. viridis	Green ephedra	P	N													
Eriogonum heracleoides	Whorled buckwheat	P	N					X								
Forestiera neomexicana	New Mexican forestiera	P	I					X		X						
Fraxinus pennsylvanica	Green ash	P	I													
Gutierrezia sarothrae	Broom snakeweed	P	N													
Halimodendron halodendron	Siberian salttree	P	I							X	X					
Kochia americana	Gray molly	P	N													
Kochia prostrata	Forage kochia	P	I							X					X	X
Lonicera tatarica	Tatarian honeysuckle	P	I					X							X	
Lycium barbarum	Matrimony vine	P	I					X		X	X		X			X

(con.)

Species	Common name[2]	Duration[3]	Origin[4]	Sites[5]												
				TM	TS	TR	TO	T2	T4	T5	T8	T9	T10	T11	T13	T17
Malus baccata	Siberian crab	P	I					X								
Morus alba var. *tatarica*	Russian mulberry	P	I													
Opuntia species	Pricklypear species	P	N								X					
Peraphyllum ramosissimum	Squaw-apple	P	N					X		X				X		
Pinus edulis	Pinyon pine	P	N													
Populus fremontii	Fremont cottonwood	P	N					X								
Prunus americana	American plum; pottawattami	P	N					X								
P. andersonii	Anderson peachbrush	P	I										X		X	
P. besseyi	Western sandcherry	P	I					X								
P. fasciculata	Desert peachbrush	P	N					X								
P. siberica	Sloe cherry	P	I													
P. spinosa	Blackthorn	P	I													
P. tomentosa	Nanking cherry	P	I					X								
P. virginiana var. *melanocarpa*	Black common chokecherry	P	N					X			X					
Potentilla fruticosa	Bush cinquefoil	P	N													
Purshia tridentata	Antelope bitterbrush	P	N					X		X			X			
Quercus gambelii	Gambel oak	P	N					X					X			X
Rhus glabra	Rocky Mountain smooth sumac	P	N													X
R. aromatica var. *trilobata*	Skunkbush sumac	P	N					X	X						X	
Ribes aureum	Golden currant	P	N						X		X					
Robinia pseudoacacia	Black locust	P	I													
Rosa hansenii	Hansen rose	P	I													
Rosa species	Rose species	P	?					X								
R. woodsii	Woods rose	P	N												X	X
Salix purpurea	Purpleosier willow	P	I													
Salix species[8]	"Black" willow	P	?													
Sambucus cerulea	Blueberry elder	P	N													
Sarcobatus vermiculatus	Black greasewood	P	N													X
Shepherdia argentea	Silver buffaloberry	P	N					X							X	X
Sorbus scopulina	American mountain-ash	P	N					X								
Symphoricarpos oreophilus	Mountain snowberry	P	N					X			X		X			
Syringa villosa	Late lilac	P	I													
S. vulgaris	Common lilac	P	I													
Syringa species	Lilac	P	I						X							
Tetradymia canescens	Gray horsebrush	P	N													
T. spinosa	Spiny horsebrush	P	N													
Ulmus parvifolia	Chinese elm	P	I													X
Yucca species	Yucca species	P	N					X								

[1]Includes all species encountered, not just those planted on the sites listed. Some of the Salina Canyon sites (table 1) are not included; compare table 1 with footnote 5, below.

[2]From Bailey Hortorium Staff 1976, Plummer and others 1977, and Albee and others 1988.

[3]A = annual; B = biennial; P = perennial.

[4]I = introduced including plants native to North America but not to Utah; N = native to Utah.

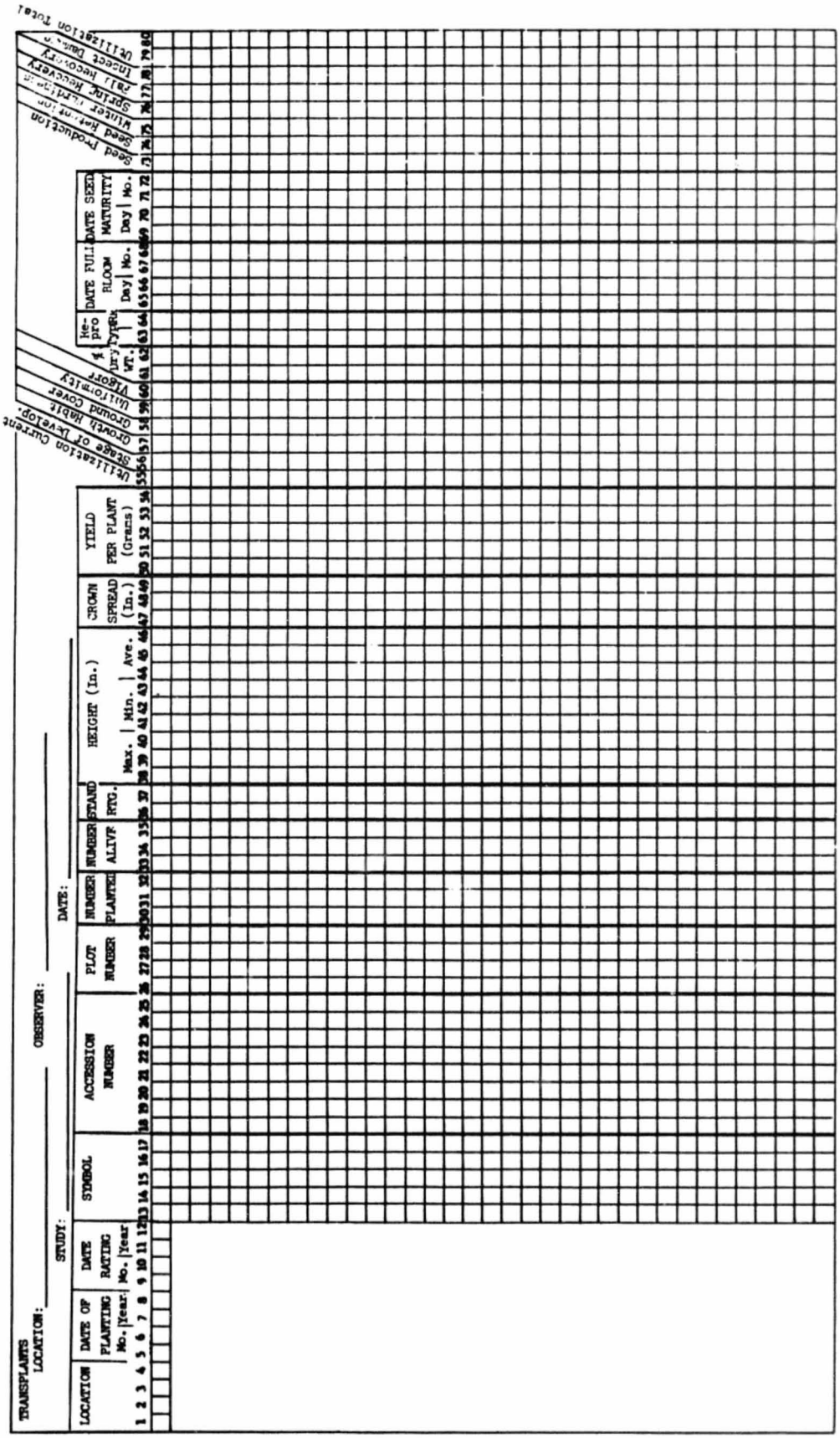
[5]Site key (see table 1): N = Nephi Canyon; F1 = Fairview Canyon, site 1; F2 = Fairview Canyon site 2; F3 = Fairview Canyon site 3; F4 = Fairview Canyon site 4; F5 = Fairview Canyon site 5; F6 = Fairview Canyon site 6; ES = Ephraim Canyon sainfoin; EP = Ephraim Canyon penstemon; EK = Ephraim Canyon kochia; EG = Ephraim Canyon grass; EB = Ephraim Canyon snowberry; EW = Ephraim Canyon wormwood; K = Kochia; FS = fourwing saltbush south of Salina; F0 = fourwing saltbush I-70 on ramp, south of Salina; FF = fourwing saltbush I-70 off ramp, south of Salina; W1 = winterfat direct seedings, Salina Canyon cut 1; W18 = winterfat direct seedings, Salina Canyon cut 18; W20 = winterfat direct seedings, Salina Canyon cut 20; B = basin saltbush seeding; D10 = direct seedings, Salina Canyon cut 10; D17 = direct seedings, Salina Canyon cut 17; D19 = direct seedings, Salina Canyon cut 19; TM = transplants, south of Manti; TS = transplants, near Sterling; TR = transplants, near Redmond; TO = transplants, I-70 on ramp near Salina; T2, T4, T5, T8, T9, T10, T11, T13, T17 are transplants near Salina Canyon roadcuts 2, 4, 5, 8, 9, 10, 11, 13, and 17.

[6]Includes *Agropyron desertorum* (standard crested wheatgrass).

[7]Found only at roadcut 14, Salina Canyon.

[8]Found only at roadcut 6, Salina Canyon.

APPENDIX B: COPY OF TRANSPLANT RATING FORM



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APPENDIX C: COPY OF DIRECT SEEDING RATING FORM

DIRECT SEEDING

Location _____ Observer _____

Study _____ Date _____

LOCATION	DATE OF PLANTING Mo.	Year	DATE OF RATING Mo.	Year	Species Type	SYMBOL	ACCESSION NUMBER	PLOT NUMBER	NO. PLANTS	STAND	HEIGHT (in) Leaf	Stem or culm	CROWN SPREAD (in)	YIELD PER PLANT (grams)	Rk.	Utilization Current	Stage of Development	Growth Habit	Ground Cover	Uniformity	Vigor	% Dry Weight	Repro Typ	Rk	DATE FULL BLOOM Day	Mo.	DATE SEED MATURITY Day	Mo.	Seed Production	Seed Retention	Winter Hardiness	Spring Recovery	Fall Recovery	Insect Damage	Seedling Vigor	Utilization Total
1 2 3 4	5 6	7 8	9 10	11 12	13 14	15 16 17 18 19 20	U 21 22 23 24 25 26 27 28	29 30 31 32	33 34 35	36 37	38 39	40 41 42	43 44 45	46 47 48 49 50	51 52	53	54	55	56	57	58 59	60 61	62 63	64 65	66 67	68 69	70 71	72	73 74	75	76	77	78	79 80

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APPENDIX D: SUMMARY DATA FOR SPECIES TRANSPLANTED ON SALINA CANYON AREA ROADCUTS BY SITE

Species	Sites[1]	Number of individuals[2]	Percent survival[2]	Average height[2]	Average crown diameter[2]	Average uniformity[2]	Average vigor[2]	Average utilization[2]	Recruitment
				------ *cm* ------					
Grasses (N = 10, 12.5%)									
Agropyron cristatum	10	20	[3]?	[3]?	[3]?	[3]?	[3]?	[3]?	[3]?
A. intermedium	10	32	25	57.0	[4]?	9.0	9.0	0	Excellent
A. repens	10,12,13	293	[5,6]?	39.3	??	8.5	9.0	0	[5,8,9]Excellent
Bromus inermis	10	30	6.7	45.0	45.0	9.0	8.0	0	0
Dactylis glomerata	10	25	4.0	63.0	50.0	9.0	9.0	0	0
Elymus cinereus	10	25	16.0	146.0	97.0	9.0	9.0	0	0
E. giganteus	10	30	3.3	158.0	147.0	7.5	9.0	0	0
E. salinus	13	62	19.4	60.0	68.0	4.0	8.5	0	[10]Good
Poa pratensis	13	30	60.0	18.0	24.0	—	8.0	0	0
Sporobolus airoides	8,13	57	40.7	47.5	46.0	7.0	8.5	0	0
Forbs (N = 6, 7.5%)									
Achillea millefolium spp. *lanulosa*	10	35	2.9	18.0	58.0	—	8.0	0	0
Artemisia ludoviciana	10	77	[11]?	23.3	62.0	7.0	8.3	0	[11]0
Chrysanthemum balsamita	10	28	3.6	57.0	71.0	—	9.0	0	0
Iris germanica	1-6,10	1,399+	11.1	20.5	23.9	5.9	6.5	0.2	[12]Excellent
Onobrychis transcaucasia	7	12	8.3	27.0	24.0	—	7.0	3.0	0
Sphaerophysa salsula	12	12	[13]?	[13]?	[13]?	7.0	8.0	0	[14]Excellent
Shrubs and trees (N = 64, 80.0%)									
Acer species(0)	5	25	16.0	8.0	8.0	7.0	6.0	0	0
Acer species(1)	5	20	5.0	3.0	4.0	—	4.0	0	0
Acer species(2)	5	20	10.0	11.0	16.0	6.0	4.0	0	0
A. ginnala	5	10	40.0	8.0	6.0	8.0	8.0	0	0
Amelanchier alnifolia	5,11,12	40	38.3	18.0	36.7	7.0	7.7	0.7	0
Artemisia abrotanum	5,6,8, 10,12	1,225	36.2	67.4	45.4	6.2	8.0	0	[15]Some
A. cana	5	100	27.0	21.5	22.8	6.8	8.0	0	[16]Excellent
A. nova	2	165	60.4	27.2	41.0	6.5	7.8	0	0
A. pygmaea	8	25	88.0	16.0	29.0	8.0	9.0	0	0
A. tridentata	2,8-10,13	597	46.6	63.3	65.7	6.8	8.3	0	0
A. tridentata ssp. *tridentata*	10	86	41.9	63.7	55.7	6.7	8.3	0.2	0
A. tridentata ssp. *vaseyana*	11	60	60.0	35.0	33.0	7.0	9.0	[17]0	0
Atriplex canescens	3,7,8,10	88+	25.4	60.5	67.0	6.0	8.2	0.8	0
A. confertifolia	13	20	100.0	24.0	55.0	4.0	9.0	0	0
Caragana arborescens	5,6,10,12	66+	29.2	80.0	87.8	7.5	8.0	0.5	0

(con.)

Species	Sites[1]	Number of individuals[2]	Percent survival[2]	Average height[2]	Average crown diameter[2]	Average uniformity[2]	Average vigor[2]	Average utilization[2]	Recruitment
				------ *cm* ------					
C. arborescens var. *pygmaea*	10	31	6.5	23.0	26.0	9.0	9.0	0	0
C. brevispina	8	51	23.5	64.0	29.0	4.5	8.5	1.0	0
C. microphylla	8,10,13	110	7.7	52.2	25.5	5.0	7.0	1.0	0
Ceanothus martinii	5,10	31	12.0	27.5	77.0	8.0	9.0	2.5	0
C. velutinus	5	20	5.0	10.0	39.0	—	9.0	0	0
C. lanata	7	83	10.8	29.0	20.3	5.7	7.0	0	0
Cercocarpus ledifolius	13	+	+	69.0	60.0	—	8.0	3.0	0
C. montanus	7	28	21.4	56.5	77.0	7.5	7.5	2.0	0
Chrysothamnus nauseosus	5,7-10	395	29.6	59.4	59.9	6.3	8.2	0	0
C. nauseosus ssp. *hololeucus*	8,10	102	12.0	104.5	92.8	8.0	9.0	0	0
C. nauseosus var. *consimilis*	8	31	32.2	66.0	74.0	7.0	9.0	0	0
C. nauseosus var. *salicifolius*	5	75	8.0	21.0	17.5	6.0	7.0	0	0
Colutea arborescens	5,6,8, 10,12	149+	42.8	98.0	117.8	7.1	9.0	3.2	0
Cotoneaster acutifolia	5,12	21	60.9	20.0	31.0	7.0	9.0	[17]0	[18]Good
Cowania stansburiana	5	13	61.5	26.5	26.0	7.0	8.5	2.0	0
Elaeagnus angustifolia	5,6,13	44+	33.3	99.6	97.5	5.0	8.4	0.1	0
E. commutata	5	28	85.7	98.0	86.0	8.0	9.0	2.0	[19]Excellent
E. umbellatum	5	10	40.0	36.0	39.0	8.0	9.0	0	0
Ephedra nevadensis	8,10,13	67+	7.4	28.9	32.4	7.5	7.3	2.1	0
Eriogonum heracleoides	5	645	1.7	106.0	33.0	7.0	9.0	3.0	0
Forestiera neomexicana	5,7	385	31.2	19.2	15.9	4.8	6.6	0	0
Halimorlendron halodendron	7,8	26	33.0	94.5	71.5	5.0	8.0	0	0
Kochia prostrata	7,12,13	73	55.1	39.7	48.5	6.0	8.8	0	[20]Good
Lonicera tatarica	5,12	53	19.8	23.8	21.5	6.5	7.2	1.0	0
Lycium barbarum	5,7,8,10,13	271	64.3	80.7	63.2	6.1	8.0	0	[21]Excellent
Malus baccata	5	18	77.8	18.0	26.0	6.0	8.0	3.0	0
Opuntia species	1,2,8	148	5.6	6.6	8.6	6.2	6.9	0	0
Peraphyllum ramosissimum	5,7,11	158	48.2	31.1	41.4	7.2	8.3	0	0
Populus fremontii	5	20	15.0	40.0	56.0	8.2	9.0	0	0
Prunus americana	5	35	22.9	9.5	7.0	6.0	7.0	0	0
P. andersonii	10,12	195	6.8	20.2	18.0	7.0	7.5	0	Some
P. besseyi	5	135	48.3	14.9	13.5	6.3	7.6	0.1	0
P. fasciculata	5	20	5.0	33.0	46.0	—	8.0	0	0
P. tomentosa	5	10	70.0	14.0	8.0	4.0	7.0	0	0
P. virginiana var. *melanocarpa*	5,8	50	4.0	17.5	23.0	9.0	8.0	0	0
Purshia tridentata	5,7,10	256	9.6	39.6	107.9	7.4	9.0	[22]2.5	0
Quercus gambelii	5,10,13	46+	9.4	14.2	14.7	7.0	7.0	0.2	0
Rhus glabra	10,13	26+	15.0	23.8	21.0	—	6.0	0.5	0
R. aromatica var. *trilobata*	5,6,12	113	59.5	19.6	18.0	4.6	7.4	0	0

(con.)

Species	Sites[1]	Number of individuals[2]	Percent survival[2]	Average height[2]	Average crown diameter[2]	Average uniformity[2]	Average vigor[2]	Average utilization[2]	Recruitment
				------ cm ------					
Ribes aureum	6,8	30	54.6	26.5	24.0	6.5	7.0	2.3	0
Rosa species	5	214	68.2	21.8	15.6	6.3	6.9	1.0	[23]0
R. woodsii	12,13	28+	53.6	42.6	40.4	—	7.6	0	[24]Excellent
Sarcobatus vermiculatus	13	+	+	34.5	47.5	—	6.1	0	0
Shepherdia argentea	5,12,13	206+	22.1	49.8	55.7	7.0	7.8	1.0	[25]Excellent
Sorbus scopulina	5	72	25.0	10.0	6.0	7.5	7.0	0	0
Symphoricarpos oreophilus	5,8,10	538	48.6	30.1	33.2	6.3	8.0	0.3	0
Syringa species	6	+	+	30.0	27.0	2.0	4.0	0	0
Ulmus parvifolia	13	+	+	50.7	54.4	—	6.1	0.4	Some layering
Yucca species	5	28	64.3	18.0	32.0	6.0	9.0	0	0

[1]Sites are number coded as follows: 1=South Manti, 2=North Sterling, 3=Redmond, 4=Interstate 70 on-ramp; South Salina, 5=roadcut 2, 6=roadcut 4, 7=roadcut 5, 8=roadcut 8, 9=roadcut 9, 10=roadcut 10, 11=roadcut 11, 12=roadcut 13, 13=roadcut 17. See table 1 for more precise locations.

[2]Only from those rows where some survived. A + in the number of individuals column indicates that an additional unknown number was planted. A + in the percent column indicates there were survivors, but the percent is unknown. Percent survival is based on known numbers only and is averaged by site (not weighted by individual number of plants). Height, crown, uniformity, vigor, and utilization are also averaged by site (not weighted). — means no data recorded.

[3]Since *Agropyron cristatum* was seeded all over the cut, it is impossible to tell what was transplanted here.

[4]No crown given for *Agropyron intermedium*, because the species has spread out to form a patch up to 9 m (29.5 ft) across.

[5]*Agropyron repens* has spread extensively quite uniformly over an area 4.5 by 12.5 m (14.8 by 41 ft) in one planting of four rows with 25 original transplants each and one with 28 transplants at site 10.

[6]*Agropyron repens* has spread so extensively beyond the original rows it is impossible to tell how many original transplants survived. The spread extended from 1.5 m (5 ft) to 2 m (6.5 ft) at site 13.

[7]Unable to determine crown of original plants because *A. repens* spread extensively.

[8]*Agropyron repens* spread 1.5 m (5 ft) along row at site 12.

[9]*Agropyron repens* spread 1.5 to 2 m (5 to 6.6 ft) along row at site 13.

[10]*Elymus salinus* spread 1 m (3.3 ft).

[11]*Artemisia ludoviciana* from three accessions survived. Four of 25 transplanted from Snow Field Station survived, but did not spread; one of 22 plants from Millville survived and spread out almost 2 m (6.6 ft) across; the transplants from Major's Nursery (north) spread up into *A. repens* rows and cover one area 1.8 by 9 m (6 by 30 ft) and one area 2 by 2 m (6.6 by 6.6 ft). The two areas are 3 m (10 ft) apart. Because of extensive spread, it is not possible to determine survival percentages.

[12]Because *Iris* at south Manti (site 1) spread considerably, the original rows are no longer obvious. Two clumps are now located outside of the original block. At the on-ramp site (site 4), *Iris* increased from 43 alive in 1976 to 76 alive in 1986.

[13]Rhizomatous nature precluded counting individuals.

[14]*Sphaerophysa* increased from 12 to 87 plants in an area 16 by 6 m (52.5 by 19.7 ft).

[15]*Artemisia abrotanum* showed some spread by rhizomes in one row at site 5; showed three young plants at site 6; and showed some layering at site 11.

[16]*Artemisia cana* had two to three times more young plants growing along the original rows than had been planted.

[17]No current use. Has been hedged in the past.

[18]*Colutea arborescens* has spread out 1.5 m (5 ft), with some seedlings at site 5.

[19]*Elaeagnus commutata* spread out 2 m (6.6 ft) up and down the hill from the original row. There were 270 new plants along the row.

[20]*Kochia prostrata* row at site 7 has spread up to 1.3 m (4.3 ft); at site 13 it has spread up to 1 m (3.3 ft) with 22 new plants.

[21]*Lycium barbarum* shows some spread by layering at site 5; spread by seed at cut 5 with 22 young plants within 1.5 m (5 ft) uphill from the row; vigorous spread of 1.5 m (5 ft) at site 8, excellent for this site; excellent spread at site 10, 3 m (9.8 ft) downhill from the row; excellent spread at site 13, 1 m (3.3 ft) above and below the row, with 44 young plants.

[22]Heavily hedged.

[23]*Rosa* species spread up to 0.5 m (1.6 ft).

[24]*Rosa woodsii* has spread vegetatively over 2 m (6.6 ft) downhill from the row, with 52 new plants at site 12.

[25]*Shepherdia argentea* has spread 1.5 to 2 m (5 to 6.6 ft). One row with 11 original plants now has 46 new ones.

U.S. GOVERNMENT PRINTING OFFICE 1993-774-041/61032

Blauer, A. Clyde; McArthur, E. Durant; Stevens, Richard; Nelson, Sheldon D. 1993. Evaluation of roadside stabilization and beautification plantings in south-central Utah. Res. Pap. INT-462. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 65 p.

Numerous roadside plantings at semiarid sites in the south-central Utah counties of Juab, Sanpete, and Sevier were intended to stabilize roadsides with plants harmonizing with natural vegetation. The plantings, originally for demonstration, began in the 1950's. They included bareroot transplants and direct seedings. Soils and geologic substrates at six sites were analyzed for 15 characteristics. Plant performance and survival was summarized for 37 sites. Thirty species established well by direct seeding and 62 species established well from transplants. Numerous other species have also persisted at the planting sites but are not as vigorous or as well adapted. Direct seedings were principally grasses and forbs; the transplants were mainly shrubs. Thirty-six species showed enough recruitment to sustain themselves on the sites.

KEYWORDS: direct sowing, transplanting, grasses, forbs, shrubs, recruitment, roadside plants, roadside plantations, roadsides

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